WHALE OBSERVATION AND WHALE MARKING OFF THE COAST OF CHILE IN 1964

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ABSTRACT

The voyage of the whalecatcher *Indus XIV* to observe and mark whales off the coast of Chile between 28° and 37°S in November-December 1964 repeated the track of a similar voyage in October-November 1958, and a major object was to compare the abundance of exploited whale species after six years.

Four blue whales sighted in 1964 prompts a discussion on *Balaenoptera musculus intermedia* and *B. m. brevicauda* off Chile.

The abundance of fin whales had drastically reduced from 5.1 per 100 miles sailed in 1958 to 0.1 in 1964. This is attributed to Antarctic whaling and also, in 1964–66, to intensive fin whaling off Chile, and it is recommended that the Permanent Commission of the South Pacific prohibit the taking of fin whales off Chile and Peru until the stock shall have recovered.

One sei whale was sighted in 1964, and the sei whales and Bryde's whales off Chile are discussed.

In November-December 1964 there were sighted 11.9 sperm whales per 100 miles sailed compared with 1.7 in October-November 1958. This is attributed to a seasonal influx into the area of the breeding stock moving southwards. Thus it is not suggested that the sperm whale stock had increased between 1958 and 1964, but there was no evidence of a decline.

Results on the distribution in 1958 and 1964 of the different classes of sperm whale schools, in relation to surface temperature, do not support the proposal of an orderly segregation across the Humboldt Current from cold to warmer water of solitary males, bachelor schools and female schools. The results lead to a review of sperm whale distribution and surface temperature in other seas, and it is concluded that in the southern hemisphere the temperatures at the subtropical convergence are in general those at the limits of

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female distribution.

The large Humboldt Current squid, *Dosidicus gigas*, is important in the diet of sperm whales of the Southeast Pacific, and an unsuccessful attempt was made to correlate the distribution and abundance of sperm whales with those of *Dosidicus gigas*, as revealed by squid fishing during night stations worked in 1964.

The distribution and abundance of blackfish, tentatively identified as *Globicephala melaena edwardi*, were very similar in 1958 and 1964, the abundance being 11.0 per 100 miles sailed in 1964 and 13.2 in 1958. These results were to be expected from an unexploited species. It is recommended that the blackfish off Chile be exploited by a controlled fishery.

There is a critical review of sightings in Chilean seas of whales recorded as *Hyperoodon planifrons*. An unidentified toothed whale sighted in 1964 is described, and also dolphins, believed to be *Tursiops* sp., and porpoises, *Phocoena* sp., which lead to a review of the species of *Phocoena* and *Cephalorhynchus* described from the Southeast Pacific.

One fin whale and 53 sperm whales were marked in 1964. Two of these sperm whales have since been recovered, one showing a local displacement of the stock, and the other, recovered from Antarctic Area I, giving direct evidence of the migration into the Antarctic of male sperm whales from the breeding stock of low latitudes.

There are discussed two recoveries from other whale marking voyages off Chile since 1958. A recovery of a Soviet mark is evidence that the same fin whales are moving off the coast of Chile from year to year, and a sei whale marked off southern Chile and recovered in Antarctic Area II after 9 years shows that sei whales have a migration route between Chile and the Antarctic similar to the route established for fin whales by whale marking in 1958.

Because of this direct evidence that the same fin whales, sei whales and male sperm whales are being exploited in the Southeast Pacific and in the Antarctic, there is urgent need for close cooperation between the Permanent Commission of the Southeast Pacific and the International Whaling Commission.

There are described the results of fishing for fish and squid during 18 brief oceanographical stations when the ship was stopped at night. The squids were all *Dosidicus gigas* and there are notes on feeding and length at sexual maturity in this species.

INTRODUCTION

Expeditions to observe and mark whales began in South America with voyages off the coast of Chile in 1958 and from the coast of Ecuador towards and beyond the Galápagos Islands in 1959. Observations of whales on these voyages, which were undertaken at the same time of the year (October-November), gave valuable results on the distribution and relative abundance of the various species in the areas surveyed, and off Chile they demonstrated a ground for fin whaling on the oceanic edge of the Humboldt Current which had not previously been exploited: the marking of fin whales off Chile, by subsequent recoveries of marks in Area II

of the Antarctic, established that the fin whales hunted from the coast of Chile in spring are a migrant stock also exploited by pelagic whaling in the Antarctic in summer (R. Clarke, 1962; translation in Spanish, 1963). A further expedition was conducted off the coast of Chile in 1964 and is the subject of this report. Since 1964 there have been additional cruises off Chile (Aguayo, 1966; Aguayo and Maturana, 1966, *unpublished reports*), and some whale marking has been conducted in Peruvian seas (Mejia, 1964; Mejia and Poma, 1966).

We here present the results of the expedition off the coast of Chile in 1964. The objects were to resume the marking of whales, and, by repeating the tracks of the voyage of 1958 at the same time of the year, to learn something of the effects of whaling by comparing the quantities of whales sighted and their distribution after a lapse of six years. The voyage in 1958 was conducted in the whalecatcher *Indus X* between 28° and 36°S from 21 October to 6 November (Fig. 2). In the event, the voyage of 1964, conducted in the whalecatcher *Indus XIV*, faithfully repeated the tracks of *Indus X*, with a small extension added to the south (Fig. 1), but took place a month later in the year, from 24 November to 17 December. This was because of delays which could not be avoided. Whales in their seasonal rhythms are moving all the time, more or less, so that this difference of a month had to be taken into account in our comparisons, although it does not invalidate our major conclusion that the sperm whale stock in the area surveyed off Chile in 1964 showed no depletion after six years, whereas the fin whale stock had been heavily depleted.

Although the principal results of the voyage of 1964 were submitted by the first author to the government and the whaling industry of Chile in an interim report dated 5 January 1965, we have only now been able to complete the present report for publication in detail. Besides the main account on whales, we discuss as relevant the fishing for squid which was a part of the brief oceanographical stations worked at night whilst the ship lay drifting. Fifty three sperm whales and one fin whale were marked during this expedition.

THE VOYAGE

The expedition of 1964 was conducted between 24 November and 17 December in the chartered whalecatcher *Indus XIV* (Captain José Porra) as two cruises which repeated the tracks of the expedition of 1958 (Fig. 2), with a small extension to the south made possible by the time at our disposal (Fig. 1). Our track lay in the upwelling region across the breadth of the Humboldt Current; throughout the voyage the water temperature at the surface was taken every two hours, with usually an additional observation of temperature whenever whales were sighted. Once or twice we had good reason to continue sailing after dark, but otherwise it was our practice to stop engines at dusk and lie each night, so as to avoid missing whales in the hours of darkness. Thus, as on the expedition of 1958, we were able each night to make regular observations and collections in the current, including fishing for fish and squid.

On the first cruise we sailed from Valparaíso on 24 November to explore the northern part of the area. In the following days, as we continued in the track of the expedition of 1958, first WSW across the body of the current, then northerly, and then east again to close the coast, there were two sightings of solitary whales (believed by Captain Parra to be bottlenosed whales), plenty of blackfish, and on two occasions schools of a small whale which was of great interest since it could not be identified, and which is discussed at length on p. 150. However, no great whales were seen until the morning of 28 November, when, steaming northwards and parallel to the coast some ten miles distant, we sighted near Punta Lengua de Vaca the only sei whale we were to encounter on this expedition. Later the same day we came upon the first sperm whales; we marked nine out of a group of 16 when 11 miles west of Isla Choros which is one of the chain of islands strung along the coast, between 29°00'S and 29°35'S, northward of Coquimbo. As we steamed north past the islands the following day, 33 sperm whales were seen and three were marked. At 1300 we were at the latitude of Huasco, being the furthest north explored during the expedition of 1958. We decided to search further north during the remainder of this day, but had sighted only two more sperm whales when darkness fell; we turned south again, sailing through the night to pick up next morning, 30 November, the track of 1958 in daylight. Sailing southwards towards Coquimbo we again approached the chain of islands and came upon 30 sperm whales off Isla Chañaral, the most northerly of the chain: fifteen of these whales were marked. That same afternoon, when three miles west of Isla Pájaros, we marked six from a group of schools amounting to 26 sperm whales. We had not long resumed our course when we sighted a magnificent concentration of sperm whales, comprising 90–110 whales within an area five miles long by three miles wide. There were harem schools, nursery schools, and schools which could not be classified, being either mixed schools of immature males and females, or bachelor schools. The various schools split and regrouped a good deal, and at one time nearly all the whales in the area had joined in five schools of 30, 28, 20, 8 and 8 whales. Many of the whales were less than 36 ft (11.0 m) long, which we consider the minimum length at which a whale can be marked with certainty that it will not be harmed by the mark (see p. 155). Nonetheless, we managed to mark 19 of the bigger whales before the light began to fail and we resumed our course for Coquimbo, where we were expected for water and provisions that evening. Next day, sailing from Coquimbo again in the track of the expedition of 1958, we observed several large schools of blackfish, and a few dolphins, but no great whales. On the afternoon of 2 December, reaching our furthest west on this leg during the expedition of 1958, we used the remaining hours of daylight to explore further west as far as 75°W, where we turned back, having seen no cetaceans all day, and steamed ESE through the night to pick up the track of 1958 next day. Again no cetaceans were seen as we sailed diagonally across the current to complete the first cruise in Valparaiso on the afternoon of 4 December. Conditions of wind and sea for sighting whales had been good throughout the cruise.

After bunkering in Valparaíso we sailed towards midday of 7 December on

the second cruise which explored the southern part of the area. Following the line of the coast as far as Constitución, according to the trace of 1958, we first went close inshore there to look unsuccessfully for a seal rookery reputed to inhabit Piedra de la Iglesia, and afterwards made our departure from the coast. Sailing westward across the current we sighted and marked a solitary fin whale on 9 December, 97 miles west of Constitución ; this was the only fin whale we saw during the expedition. Later, on 9 December, we encountered two solitary sperm whales, one of which was marked, and a blue whale which was chased unsuccessfully. At 0700 on 10 December, at the position corresponding to Station I_{10} in Fig. 2, we left the track of 1958 to begin the short extension which time allowed us. As we changed course a pair of blue whales were sighted, and afterwards a solitary blue whale, but these whales were chased unsuccessfully. The new course took us WSW as far as 36°S, 76°W, and then ESE across the current to Talcahuano, where we arrived on the afternoon of 11 December, having seen only the blow of a whalebone whale afar, and some porpoises. At Talcahuano we took water and provisions, and sailed on 12 December NW×W towards the position of Station I_{10} (35°20′S, 75°23′W) so as to resume the track of 1958. This position was reached at 0820 on 13 December ; shortly afterwards the weather deteriorated, and the ship was hove-to in heavy seas and a strong wind, until the morning of 14 December when conditions improved and we resumed our course. Again on 15 December conditions for sighting whales were poor, and we hove-to for some hours, not wishing to leave this area, where we might hope to find baleen whales, until conditions had improved. Course was resumed in the afternoon, and so we continued in good weather for the rest of the voyage towards Valparaíso, where we arrived to complete the expedition in the early hours of 17 December, having called at the whaling station of Quintay for a few hours on 16 December. During the four days since leaving Talcahuano we had seen no great whales.

WHALE OBSERVATION

Figure 1 shows the positions and numbers of the kinds of whales sighted in 1964. For comparison, the corresponding chart for the expedition of 1958 is reproduced from R. Clarke (1962, Fig. 2) as Fig. 2. Details of schools (Table 6 in the present paper and Table 3 in R. Clarke (1962)) are not necessarily shown in the charts which give only the aggregate numbers of whales observed around a particular geographical position, called a ' sighting ' : this is an encounter with whales which may refer to any number of animals, from one to a large concentration comprising numerous schools and perhaps single whales also. There are indicated on the charts those parts of the track where now and then a vessel sailed for a period in darkness, or where, because of bad visibility or heavy weather, the conditions for sighting whales were poor (see R. Clarke and Ruud, 1954). Table 1 is an annotated record of all whales, dolphins and porpoises observed during the voyage of 1964.

The abundance of the various species of whales are expressed as the numbers of whales sighted per 100 miles of effective distance sailed for whale observation.

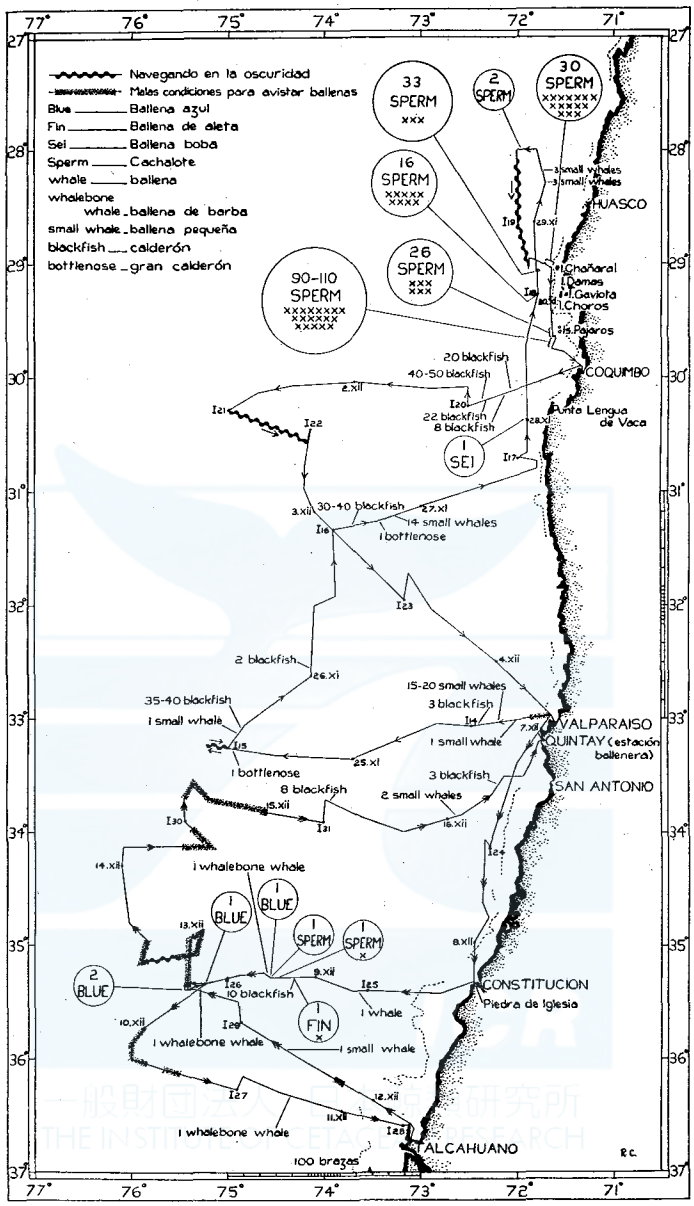

Fig. 1. The voyage of the whalecatcher *Indus XIV* off the coast of Chile between 24 November and 17 December 1964. The species and numbers of whales sighted and the numbers of whales marked are shown; a cross represents each whale marked. The dates are noon positions. Brief oceanographical stations, I_{14} to I_{31}, are also plotted.

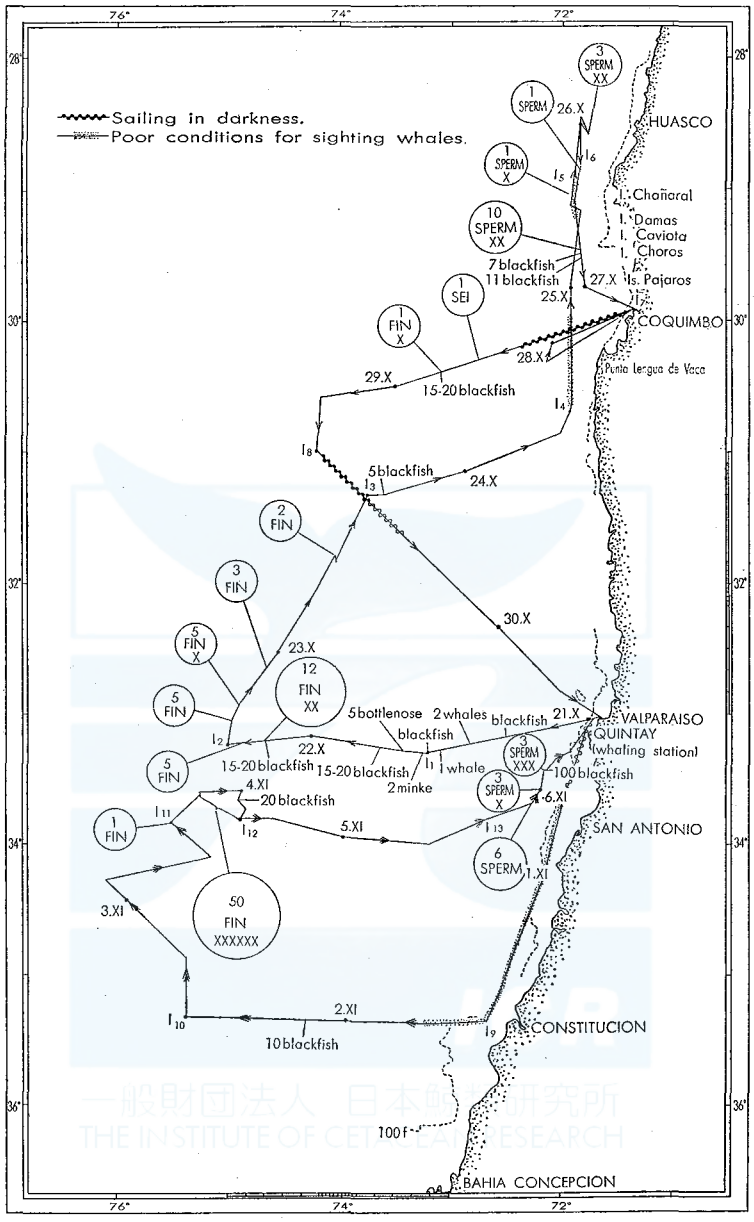

Fig. 2. The voyage of the whalecatcher *Indeus X* off the coast of Chile between 21 October and 6 November 1958. Reproduced with permission from *Norsk Hvalfangst-tidende*, 1962, p. 271.

TABLE 1. WHALES, DOLPHINS AND PORPOISES SIGHTED OFF THE COAST OF CHILE IN 1964

Species	Date and Time	Position	Surface temp. °C	Nos. of whales	Schooling	Direction	Remarks
Blue whale							
Balaenoptera musculus	9. xii/1555	35°17′S, 74°33′W	17.0°	1	Solitary	SW	Length 21.5–23 m (70–75 ft).
	10. xii/0705	35°23′S, 75°26′W	17.6°	2	(Separate)	SW	Both about 20 m (65 ft). They were separate at first. One was moving SW and was later joined by the other when chased.
	— /0750	35°20′S, 75°13′W	17.6°	1	Solitary	S	
Fin whale							
Balaenoptera physalus	9. xii/1305	35°16′S, 74°18′W	17.5°	1	do.	SSW	Length 16.5–18 m (55–60 ft). Accompanied by 10 blackfish and 6–8 dolphins
Sei whale							
Balaenoptera borealis	28. xi/0745	30°22′S, 71°55′W	14.5°	1	do.	S	Length about 13.5 m (45 ft)
Unidentified large whalebone whales	9. xii/1610	35°14′S, 74°35′W	17.0°	1	do.		Blowing far off
	10. xii/0840	35°23′S, 75°17′W	17.6°	1	do.		do.
	11. xii/0824	36°19′S, 74°21′W	16.2°	1	do.		Blew infrequently far off. Possibly a sei whale
Sperm whale							
Physeter macrocephalus	28. xi/1830	29°16′S, 71°47′W	15.0°	16	Two of 5	SW	Unclassified schools } Dispersed a mile or so from each other
					3 and 2	S	Batchelor schools }
					1 Solitary	S	Pl. I, Fig. 1. }
	29. xi/0705 /0815	29°03′S, 71°48′W to 29°05′S, 71°48′W	15.5°	33	4 and 6	SW	Harem schools (Pl. I, Fig. 2)
(*For further details see Table 7*)					One of 9		Harem school
					Pair		Batchelor pair } Dispersed over a wide area
					2 Solitary	SW	Small males }
					1 Solitary		Small male }
					3 pairs	SW	Unclassified }
					One of three		Unclassified }
	29. xi/1645	28°00′S, 71°58′W	18.2°	2	Pair	E	Unclassified
	30. xi	29°00′S, 71°43′W to	14.8° to				

	0715–1020 30. xi	29°02′S, 71°39′W 29°35′S, 71°38′W	16.0°	30	11, 8, 3, 8		Unclassified
	1345–1555	to 29°38′S, 71°38′W		26	8, 8 and 5 2 2 solitary 1 solitary		Nursery schools Cow and calf (Pl. II. Fig. 1) Small males Large bull } Dispersed over a wide area
	30. xi 1610–1915	29°40′S, 71°86′W to 29°45′S, 71°39′W	18.1° to 18.7°	90–110	30, 28, 20 8 and 8		This concentration, of which 94 were schooling as shown at a certain moment, included harem schools, nursery schools and unclassified schools dispersed over a wide area. There were also a few young solitary males, although these eventually joined the schools.
	9. xii/1500	35°17′S, 74°29′W	17.1°	1	Solitary	E	Large bull
	/1550	35°17′S, 74°33′W	17.0°	1	Solitary		Large bull
Unidentified large whales	9. xi/0648	35°23′S, 73°38′W	—	1	Solitary		Blowing far off
Blackfish *Globicephala melaena edwardi*	24. xi/1930	33°03′S, 72°24′W	16.2°	3	Schooling		
	26. xi/0725	33°05′S, 74°52′W	16.6°	35–40	do.	W	Chased for observation (Pl. II. Fig. 2). Colour notes (see text).
	— /1255	32°32′S, 74°08′W	17.2°	2	do.	E	
	27. xi/0712	31°18′S, 73°41′W	16.5°	30–40	do.		Accompanied by 8 dolphins.
	1. xii/1725	30°07′S, 72°04′W	16.8°	20	do.	S	Colour notes (see text)
	— /1750	30°08′S, 72°08′W	16.9°	8	do.		
	— /1855	30°12′S, 72°20′W	17.2°	22	12, 6, 4	S	
	— /1905	30°12′S, 72°22′W	17.2°	40–50	Schooling		School comprised whales of 3.7–4.6 m. (12–15 ft) with calves of about 2 m. (6 ft). Colour notes (see text).
	9. xii/1305	35°16′S, 74°18′W	17.5°	10	do.	SSW	School comprised whales of 3.7–4.9 m. (12–16 ft), but with one (a male) of about 7.5 m (25 ft). Accompanied by a fin whale and 6–8 dolphins.
	16. xii/0612	33°44′S, 73°57′W	16.4°	8	do.	S	
	— /1535	33°35′S, 72°11′W	17.2°	3	do.	NE	

Continued . . .

TABLE 1. Continued.

Species	Date and Time	Position	Surface temp. °C	Nos. of whales	Schooling	Direction	Remarks
Bottlenosed whales?	25. xi/1750	33°66′S, 74°57′W	16.3°	1	Solitary		See text.
	27. xi/0808	31°16′S, 73°26′W	16.5°	1	do.		
Unidentified small whales	24. xi/1650	33°00′S, 72°02′W	15.9°	1	Solitary		Only the flukes were seen.
	— /1755	33°02′S, 72°11′W	16.0°	15–20	Schooling	NW	Chased for observation. Length about 6.0 m. (20 ft). Notes on form and colour. See text and Pl. III. Fig. 1.
	26. xi/0705	33°08′S, 74°54′W	16.6°	1	Solitary		
	27. xi/0712	31°13′S, 73°16′W	16.7°	14	Schooling		Chased for observation. Length 4.5–6.0 m. (15–20 f). Notes on form and colour. The same species seen 1755/24. xi. See text.
	29. xi/1402	28°18′S, 71°43′W	18.2°	3	Schooling		Length about 9 m. (30 ft).
	— /1440	28°11′S, 71°41′W	18.4°	3	Schooling		
	12. xii/1738	35°55′S, 74°24′W	16.6°	1	Solitary		
	16. xii/1240	33°51′S, 72°36′W		2	Pair		
Dolphins							
Tursiops sp.	25. xi/1850	34°04′S, 75°04′W	16.2°	8–10	Schooling		Length about 2.4 m. (8 ft). Colour notes. (see text)
	27. xi/0712	31°18′S, 73°41′W	16.5°	8	do.		As those on 25. xi/1850. Notes on form and colour (Pl. III. Fig. 2). Accompanying 30–40 blackfish.
	1. xii/1830	30°11′S, 72°16′W	16.9°	6	do.	SW	Length 1.5–1.8 m. (5–6 ft). As those on 25. xi/1850.
	9. xii/1305	35°16′S, 74°18′W	17.5°	6–8	do.	SSW	Length about 2.4 m (8 ft). As those on 25. xi/1850. Accompanying a fin whale and 10 blackfish.
Porpoises							
Phocoena sp.	8. xii/1940	35°24′S, 73°32′W	17.6°	15–20	do.		Length 0.9–1.5 m. (3–5 ft). Mostly 1.2 m. (4 ft). Notes on form and colour. See text.
	9. xii/0930	35°20′S, 73°47′W	17.2°	50–60	do.	NW	As those on 8. xii/1940.
	11. xii/1005	36°22′S, 74°13′W	16.2°	20	do.	S	As those on 8. xii/1940.
	— /1010	36°22′S, 74°12′W	16.2°	6	do.		As those on 8. xii/1940.
	16. xii/1020	33°59′S, 73°07′W	16.2°	20	do.	NW	As those on 8. xii/1940.

TABLE 2. EFFECTIVE DISTANCES SAILED FOR WHALE OBSERVATION OFF THE COAST OF CHILE IN 1964 AND 1958

Miles	1964 Complete expedition	1964 In the track of 1958	1958 (R. Clarke, 1962, p. 273)
Total distance sailed, *less*	2,516	2,122	1,820
Distance sailed in darkness	162	162	99
Distance sailed in poor conditions for sighting whales	205	164	140
Approaches of ports	56	40	16
Effective distance sailed for whale observation	2,093	1,756	1,565

This 'effective distance' represents the total distance sailed less the distances sailed in darkness, in poor conditions for sighting whales, and in the approaches to ports (Table 2).

Table 3 presents the numbers of whales observed per 100 nautical miles of effective distance sailed in three sets of results: those from the complete expedition of 1964; those from this expedition less the extension to the southward, that is, following only the track of 1958; and those from the expedition of 1958 itself (R. Clarke, 1962, Table 1). In the event the extension to the south produced little of interest, apart from the blue whales seen, and for the purposes of comparing the abundance of whales we are mainly concerned with the second and third sets of results, those from the expeditions of 1964 and 1958 conducted over the same track.

Results from the two voyages may be compared because on each the sighting effort was just about the same. The ships were of similar size (*Indus X*, 292 tons; *Indus XIV*, 315 tons), and the vigilance of observation was similar, for in each ship there were at all times during daylight hours a lookout in the masthead barrel, and a whaling officer (usually the captain) and at least one scientist on the bridge. There is evidence in the results themselves that they do give a fair indication of the relative abundance of the various whale species and that comparison of the results in 1958 and 1964 is significant. Thus, the stock of blackfish off the coast of Chile is not at present exploited and therefore we may expect that in the same area in the same season the population will remain unchanged from year to year. The results show this for the same track sailed in 1958 and 1964, whether the abundance is expressed as numbers observed per 100 nautical miles of effective distance sailed (Table 3), or, since blackfish are gregarious like sperm whales, as sightings per 100 nautical miles sailed, and numbers of whales per sighting (Table 4, from Figs. 1 and 2). This is further discussed on p. 148. It may be objected that, whereas dolphins and porpoises also are not exploited, Table 3 gives quite different results for the numbers of dolphins and porpoises observed per 100 nautical miles sailed in 1958 and 1964; but here it is not expected that the results are a good indication of abundance, because the blows of these small cetaceans cannot be seen at any distance, and recording them seems to be fortuitous to some extent, depending on whether they are breaching at the time, or whether they interest themselves in approaching the vessel, or happen to be directly in its path.

TABLE 3. COMPARISON OF THE ABUNDANCE OF WHALES OBSERVED DURING TWO EXPEDITIONS OFF THE COAST OF CHILE IN 1964 AND 1958

Groups or species of whales		1964 Complete expedition			1964 Following the track of 1958			1958 (Clarke, 1962, Table 1)		
		Nos observed	Average nos.	Nos per 100 miles sailed	Nos observed	Average nos.	Nos per 100 miles sailed	Nos observed	Average nos.	Nos per 100 miles sailed
Larger Whales	All whales:	209–229	219	10.5	204–224	214	12.2	115	115	7.4
	Whalebone whales	9	9	0.4	4	4	0.2	85	85	5.4
	Blue	4	4	0.2	1	1	0.1	—	—	—
	Fin	1	1	>0.1	1	1	0.1	84	84	5.4
	Sei	1	1	>0.1	1	1	0.1	1	1	0.1
	Unidentified	3	3	0.1	1	1	0.1	—	—	—
	Sperm whales	199–219	209	10.0	199–219	209	11.9	27	27	1.7
	Unidentified large whales	1	1	>0.1	1	1	0.1	3	3	0.2
Smaller whales, dolphins and porpoises	Minke whales	—	—	—	—	—	—	2	2	0.1
	Blackfish	181–206	194	9.3	181–206	194	11.0	198–213	206	13.2
	Bottlenosed whales	2*	2*	0.1*	2*	2*	0.1*	5	5	0.3
	Unidentified small whales	40–45	43	2.1	39–44	42	2.4	—	—	—
	Dolphins	28–32	30	1.4	28–32	30	1.7	239–249	244	15.6
	Porpoises	111–126	119	5.7	85–100	93	5.3	—	—	—

* Identification as bottlenosed whales uncertain (see p. 149).

When discussing the results, it is at times helpful to refer to Table 5, showing the catches of whales from the coast of Chile in recent years (1955–1975). The table is used only in a general way, as it would be misleading to extract much from it on the comparative abundance of the different species: the catches are aggregate figures from three whaling stations (at Iquique, Quintay and Talcahuano ; see R. Clarke, 1962, Fig. 1) which in different years have pursued varying policies involving varying catching effort in regard to the selective hunting of sperm whales and whalebone whales ; for example, between 1964 and 1967 whaling from Quintay was conducted by a Japanese concession which concentrated solely on hunting whalebone whales for meat production, which explains the increase in captures from Chile of blue, fin and sei whales in those years and the reduction in the sperm whale catch (see also Aguayo, 1974).

TABLE 4. SIGHTINGS OF FIN WHALES, SPERM WHALES AND BLACKFISH OFF THE COAST OF CHILE IN 1964 AND 1958

		1964 complete expedition	1964 In the track of 1958	1958 (R. Clarke, 1962, Fig. 2)
Fin whales	Number of sightings	1	1	9
	Sightings per 100 miles sailed	0.05	0.06	0.51
	No. of whales per sighting	1	1	9.3
Sperm whales	Number of sightings	8	8	7
	Sightings per 100 miles sailed	0.38	0.46	0.45
	No. of whales per sighting	26.1	26.1	3.8
Blackfish	Number of sightings	11	11	11
	Sightings per 100 miles sailed	0.53	0.63	0.70
	No. of whales per sighting	17.6	17.6	18.7

General results

During the complete expedition of 1964 there were observed 209–224 great whales, comprising four blue whales, one fin whale, one sei whale, three whalebone whales too far away to be identified, 199–219 sperm whales, and one large whale seen afar which could have been a sperm whale or a whalebone whale. Only three blue whales and two of the unidentified whalebone whales were seen on the southerly extension of the course (Fig. 1), so that, comparing results from the same track in 1958 and 1964, large whales (all species of commercial interest) appeared to be nearly twice as abundant in 1964 (Table 3). This was because of the numbers of sperm whales seen, for a feature of the results is the great reduction in the abundance of fin whales between 1958 and 1964.

Blue whales (Balaenoptera musculus)

It is noteworthy that, whereas no blue whales were sighted in 1958, four of the species were sighted in 1964. They were far from land, towards the oceanic border of the Humboldt Current, one in the most southern part of the track of 1958 and the other three where the extension to the south had just begun (Fig. 1).

Perhaps we were not far enough south at this time of the year for blue whales in 1958, because, since modern whaling began in Chile in 1908, the south of the country, between 37° and 40°S, has been noted for blue whales (Risting, 1922, p. 558 ; Cabrera and Yepes, 1940, p. 313), whilst in recent years Aguayo (1974) has observed some farther south, between 43° and 46°S, in 1966.

The blue whales seen in 1964 were travelling southwest or south (Table 1), and might be thought, at this time of the year, to have been migrants of the main stock of southern blue whales, travelling to their summer feeding grounds in the Antarctic. But this may not be so. Dr. Tadayoshi Ichihara has suggested, from the length composition of the blue whale catch and the shape of the baleen plate, that blue whales from Chile may be pigmy blue whales (Nasu, 1966, p. 159). This sub-species of blue whale, *Balaenoptera musculus brevicauda*, has been identified and described by Ichihara (1961, 1963, 1966) from the South Indian Ocean, where in summer it is distributed between 0° and 80°E, but does not extend into the Antarctic further than 54°S, although in winter it has since been reported by Dr. R. G. Chittleborough from the west coast of Australia (Ichihara, 1966, p. 82) and by Gambell (1964) from the east coast of South Africa. The main stock of southern blue whales, whose migration extends to the ice edge in summer, is now distinguished, according to Rice and Scheffer (1968), as the sub-species *Balaenoptera musculus intermedia*. This ' main ' stock has in fact been so decimated by Antarctic whaling that it was estimated to comprise, in all oceans south of the equator, less

TABLE 5. WHALES CAUGHT FROM THE COAST OF CHILE, 1955–1975. FROM INTERNATIONAL WHALING STATISTICS (1968–1976)

Year	Blue	Fin	Humpback	Sei	Sperm	Right	Total
1955	150	359	5	32	746	6	1,298
1956	209	202	3	48	1,171	—	1,633
1957	100	69	5	39	2,299	—	2,512
1958	166	73	—	16	2,062	—	2,317
1959	80	70	3	17	2,062	1	2,233
1960	131	52	2	13	1,886	—	2,084
1961	142	16	3	13	2,160	—	2,334
1962	11	34	4	9	2,280	—	2,338
1963	31	11	1	6	1,494	—	1,543
1964	112	136	—	47	1,213	—	1,508
1965	371	265	6	439	267	—	1,348
1966	128	84	7	210	669	1	1,099
1967	65	7	—	139	533	—	744
1968	—	25	1	83	319	—	428
1969	—	—	1	31	221	—	253
1970	1	3	—	17	270	—	291
1971	1	3	—	1	246	2*	253
1972	—	—	—	15	337	—	352
1973	—	—	—	14	232	—	246
1974	—	2	—	32	130	—	164
1975	—	—	—	58	48	—	106

* ' Other whales ', not necessarily right whales.

than 1,000* animals, during 1962/63, the last season for exploiting the main stock in the Antarctic before it was completely protected by the International Whaling Commission (*Rep. int. Whal. Commn*, 1967, p. 40). Nonetheless substantial catches making a total of 676 blue whales were caught in Chile during the Japanese concession for whalemeat between 1964 and 1967 (Table 5). In view of the low estimate reported for the whole southern ' main ' stock in 1962/63, such catches from just one coastline, the coast of Chile, in the years after 1963 would scarcely be explicable if all these whales were from what was left of the main stock. This evidence alone suggests that there must exist in the Southeast Pacific a subspecies of the blue whale which does not migrate into the Antarctic and is similar to, or identical with, the pigmy blue whale *B. m. brevicauda.* Its presence has now been confirmed by Aguayo (1974) who identified ten specimens as pigmy blue whales among 168 blue whales examined in 1965/66 and 1966/67 at Quintay. It is indeed surprising, from the figures discussed here, that the proportion of pigmy blue whales was not greater in Aguayo's sample. Meanwhile it is now clear that both *B. m. intermedia* and *B. m. brevicauda* occur in the Southeast Pacific, but much needs to be discovered about their respective abundances, ranges and seasonal movements.

Fin whales (Balaenoptera physalus)

In 1964 only one fin whale was observed, on 9 December, some 96 miles due west of Constitución ; it was travelling SSW and was presumably migrating towards the Antarctic (Table 1, Fig. 1). This is an abundance of 0.1 whales per 100 nautical miles sailed, whereas on the same track in 1958 there were sighted 84 fin whales or 5.1 per 100 nautical miles sailed (Table 3). If we look at abundance in another way, as the frequency of sighting fin whales, then in 1958 they were sighted on nine occasions, and there were 9.3 whales per sighting (Table 4).

Notwithstanding these results, it is seen in Table 5 that a large catch of fin whales was in fact made from Chile in 1964. The explanation is that most of these whales were taken by the Japanese concession which was whaling from Quintay for whalebone whales for meat production between 1964 and 1967. Thus, during the expedition of 1964 when *Indus XIV* sighted only one fin whale, there were at this time four Japanese whalecatchers sighting and catching fin whales in a part of the area covered by our expedition. But there was no comparison in the sighting effort. We were informed (by Captain Parra†) that on the Japanese catchers (which were fast modern vessels fitted with echo whalefinders) there were at all times at least twelve men looking out for whales, four at the masthead (two in the barrel and one in either rigging), four on the bridge and four on the poop, with a substantial prize awarded to the first man to sight a whale. It follows that every fin whale within the vicinity of such catchers must indeed have been sighted and captured. We therefore do not consider that the catches recorded in Table 5 contradict our results, which point to a very considerable reduction in

* Gulland (1972), reviewing the earlier analyses, revised this estimate upwards to a catchable stock of about 4,000 in 1963, but his figure still seems sufficiently low to support the argument here following.

† One of us (A.A.L.) subsequently confirmed Captain Parra's information.

the fin whale population off this part of the coast of Chile between 1958 and 1964.

From recoveries in Antarctic Area II of marks fired into fin whales during the expedition of 1958, it has been established that fin whales off the coast of Chile in spring are migrating to summer feeding grounds in the Antarctic (Brown, 1960, 1961a, 1962a, 1962b ; R. Clarke, 1962). It follows that since these whales are a population in movement, and since the expedition of 1964 (24 November to 17 December) was conducted a month later than that of 1958 (21 October to 6 November), there is a little uncertainty about a strict comparison of the results. It might even be argued that in 1964 we were too late to sight more than one straggler from a fin whale population which had already moved southward out of the area ; but this would require an independent check, such as figures on the monthly catch per unit of effort from Quintay in earlier years, and these could show that fin whales in the past have been more abundant in the area later than October-November, rather than at this time, or earlier. It is important to recall that migrating whales move through an area, not as a simple block, but as a procession over a period of time, and, further, that in the Antarctic the fin whale population does not reach its peak until February. This being so, we believe that whatever may have been the effect of a difference of a month in the time of the two surveys, the expedition of 1964 showed such an impoverishment of fin whales as can only in the main be explained by overfishing of fin whales on the pelagic grounds of the Antarctic, which has brought about a severe decline in the southern fin whale population in recent years. The intensive hunting from Quintay by the Japanese concession for whalemeat would also have had its local effect, but this had only begun in 1964 and is not likely to have been more than a contributory factor at that time.

According to the Report to the International Whaling Commission of the Special Meeting on Antarctic Fin Whale Stock Assessment, held at Honolulu in March 1970 (*Rep. int. Whal. Commn*, 1971, p. 38), various estimates of the fin whale population in the southern hemisphere gave an average of about 172,000 in 1958 which had by 1964 declined to about 71,000, little more than a third of its size six years previously. Moreover, the fin whale populations which have been most severely depleted by pelagic whaling on the summer feeding grounds are those which resort to Antarctic Area II, which is the sector south of the Atlantic ; and whale marking has shown that some part, probably the major part, of the fin whales migrating off the coast of Chile do not stay in Area I, the Pacific sector due south of the route, but pass eastward through Drake Strait into Area II, where between 1960 and 1961 all the marks were recovered from four out of eleven fin whales marked off Chile in 1958 (see R. Clarke, 1962, Fig. 1 and p. 280).

Commenting on the results of whale marking, R. Clarke (1962, p. 283) observed ' . . . although the numbers of marked whales involved are too small to be conclusive, it is hard to avoid the impression that, since four whales within three years have been recaptured in the Antarctic from eleven marked off Chile, the exploitation in the Antarctic of fin whales from Chile may well be substantial '. The expedition of 1964 has shown the effect of this exploitation. Maintenance of a fin whaling industry on the coast of Chile depends on effective regulation of

pelagic whaling in the Antarctic. In an effort to build up the depleted fin whale stocks, the International Whaling Commission set the Antarctic catch limit after 1967 at a figure rather less than the best estimate for the combined sustainable yield of the southern fin and sei whale stocks (see R. Clarke, 1968), and after 1972 at a figure less than the estimate for maximum sustainable yield of the fin and sei whale stocks separately; after 1974 separate catch quotas were provided for fin whales in the Antarctic Areas I–VI; in the 1975/76 season the prescribed fin whale catch was only allowed in Area I south of Chile, until in 1976 the Commission prohibited the taking of fin whales throughout the southern hemisphere by its member nations (*Int. Commn Whal., Schedules*, 1972–1976). After the substantial catches at the time of the Japanese concession for whalemeat in 1964–1967 from the depleted fin whale stock migrating to the Antarctic off the west coast of South America, the catches in Chile have been few (Table 5) and they have diminished in Peru in recent years (*International Whaling Statistics, 1976*), which is to be expected from the known condition of the stock. There is now urgent reason for the Permanent Commission of the South Pacific to follow the example of the International Whaling Commission and prohibit the taking of fin whales from Chile and Peru until the stock shall have recovered. As R. Clarke pointed out in 1962, rational exploitation of the stocks of whales in the Southeast Pacific cannot be achieved unless there is close cooperation between the Permanent Commission and the International Whaling Commission (see also p. 159).

Sei whales (Balaenoptera borealis)

One sei whale, moving south, was sighted on the expedition of 1964, off Punta Lengua de Vaca (Table 1, Fig. 1). In 1958 also a single sei whale was sighted, farther west at about the same latitude (Fig. 2). Although little can be said of a single sighting, one would certainly expect the abundance (0.1 per 100 miles sailed) not to have changed between 1958 and 1964, because very few sei whales were captured from Chile until 1965–1967 when substantial catches contributed to the Japanese operation for meat production from whalebone whales at Quintay (Table 5).

Bryde's whale, *Balaenoptera edeni*, has now been recorded from Iquique on the coast of Chile (R. Clarke and Aguayo, 1965), and so it is possible that the sei whales seen on the expedition of 1958 and 1964 may in fact have been Bryde's whales. It is generally accepted that the two species can only be distinguished at sea if it is possible to get a good view of the top of the head which only in Bryde's whale bears a ridge on either side of the median ridge common to the head of both species (Omura, 1962). But a ship has to approach so close for a chance to make out these side-ridges that, in the normal circumstances of a survey for whales, Bryde's whale and the sei whale are not likely to be distinguished by this character. However, the form and size of the spout may also afford a clue. One of us (A. A. L.) was informed by Japanese whaling captains in 1966 that the spout of Bryde's whale is wider and lower than that of the sei whale, and this has since been confirmed to A. A. L. by Dr. Masaharu Nishiwaki. Bryde's whales in the North

Pacific are in general limited to waters of 20°C or warmer (Omura and Nemoto, 1955), or mostly to waters warmer than 18°C with very few whales penetrating to 15°C (Nemoto, 1959, p. 247). Consequently the two whales seen around 30°S in 1958 and 1964 were more likely to have been sei whales, for the surface temperature was 14.5°C at the position of sighting the whale of 1964 (Table 1, Fig. 3).

There is now direct evidence from whale marking that some at least, of the sei whales off Chile migrate like the fin whales to the Antarctic in summer (see p. 159).

Sperm whales (Physeter macrocephalus*)

Abundance. In 1964 there were sighted 199–219 sperm whales or 11.9 per 100 nautical miles sailed, compared with 27 whales, or 1.7 per 100 nautical miles sailed on the same track in 1958 (Table 3). However, since half of the whales seen in 1964 comprised the great concentration of 90–110 whales encountered south of Isla Pájaros on 30 November (Fig. 1), we should also consider the frequency of sighting sperm whales, where results for the two voyages are just about the same, being 0.46 of a sighting per 100 nautical miles sailed in 1964, and 0.45 in 1958, although the numbers of whales per sighting were seven times greater in 1964 than in 1958 (Table 4). Distribution was similar on the two expeditions in that all except two of the sperm whales seen in 1964 were close to the chain of islands stretching from Isla Chañaral southward to Isla Pájaros, where were seen half the sperm whales recorded in 1958, although in 1964 we saw none on the ' San Antonio ground ' which had provided the balance of the sperm whales seen in 1958 (Figs. 1 and 2).

The chances, then, of encountering sperm whales in 1964 and 1958 were just about the same, but in 1964 there were many more whales in the encounters. We believe that this was because, as will be explained when schooling and immigration are discussed, there were in 1964 more whales schooling and the schools were larger, due to a seasonal influx of whales into the area over the interval between October-November, when the expedition of 1958 took place, and November-December, when the survey was repeated in 1964. Thus it is not suggested that the results necessarily indicate an increase of the sperm whale stock in this area between 1958 and 1964, but they certainly do not indicate any decline in the stock during the period.

There was a sharp decline in sperm whale catches from Chile after 1964 (Table 5), but this can be explained, at least in part, by the dedication of one station (Quintay) to hunting whalebone whales for meat production, and to the low price of sperm oil which discouraged much effort in sperm whaling from the other two stations in Chile.

However, Saetersdal, Mejía and Ramírez (1963) have analysed whaling statistics from Peru, and have concluded that by 1961 sperm whales off Peru were probably already being over-exploited. Further, Arriaga (1976) cites reports (which we

* Husson and Holthius (1974) have argued convincingly that *Physeter macrocephalus*, Linnaeus, 1758 has precedence over *P. catodon*, Linnaeus, 1758 as the valid name for the sperm whale.

have not seen) by Mr. Jorge Mejía in 1964 and 1965 which claimed a progressive reduction after 1961 of the sperm whales off Paita, Peru, as shown by a diminution in the catch per catcher's days work between 1961 and 1965. (In more recent years we believe that catch per unit of effort is less reliable as an index of abundance, because part of the effort in Peru has latterly been directed towards large catches of sei (or Bryde's) whales. Now Saetersdal, Mejía and Ramírez extended their conclusions to the Southeast Pacific as a whole, on the reasonable assumption that the same sperm whale stock is being exploited from Chile and Peru. This matter is being currently investigated, and all the evidence to emerge so far, from external characters and teeth (R. Clarke, Aguayo and Paliza, 1968), from morphometry using the allometry equation (R. Clarke and Paliza, 1972) and from morphometry using canonical analysis (Machin, 1974), indicates that the sperm whales off Chile and Peru do indeed form a single, continuous stock.

Our observations at sea off Chile in 1964 did not therefore show that decline in the sperm whale population since 1958 which the results of Saetersdal, Mejía and Ramírez, and later of Mejía, would have led us to expect. However, whatever may have been the condition of the stock off Chile in 1964, it is now generally agreed that an appraisal of the present condition of the Southeast Pacific sperm whale stock is urgently required (Scientific Consultation on Marine Mammals, Bergen, 1976. Document ACMRR/MM/SC/Rep. 1, Addendum to Appendix).

Schooling. The sperm whale is gregarious and polygamous, and the significance of schooling to the reproduction and population dynamics of the species has been emphasised by R. Clarke (1956, p. 277), Gambell (1967, 1972) and Best (1970b). Detailed information on the structure of schools, that is, the sexing of the component whales, their condition of immaturity and maturity, and stages in the sexual cycle, requires that sighting from ships or aircraft of particular schools be combined (as some investigators, especially Best, have attempted) with subsequent biological examination of carcases after all or some of the individuals comprising these schools have been shot. The major difficulty in attempting to classify sperm whale schools solely by observation at sea is that small males in schools cannot be distinguished from females, unless the latter are accompanied by calves. Nonetheless, the main kinds of schools can be distinguished to a certain extent. This is because we know that, whilst males may be solitary or schooling, females are invariably in schools (R. Clarke, 1956, p. 277), and because females rarely exceed 11.7 m (38 ft) in length, so that whales judged to be longer than 11.7 m are understood to be males. Thus, *solitary* sperm whales of any size are males (Pl. I, Fig. 1). Schools where the whales are all larger than 11.7 m are *bachelor schools.* Then two kinds of schools containing females may be recognised. *Harem schools* are those where one, or sometimes two or three, large whales are together with small whales, at least one of which is known to be a female because accompanied by a calf (Pl. I, Fig. 2). In such a school one of the large whales will be the harem-master. *Nursery schools* are those of small whales (less than 11.7 m), some of which are accompanied by calves (Pl. II, Fig. 1). This is as far as the observer can go at sea, and leaves him with a number of unclassified schools. These would include (if they

could be identified) the bachelor schools of males smaller than 11.7 m, the mixed schools of immature males and females which associate ' as boys and girls go to school together ' (see R. Clarke, 1956, p. 279), and also those harem schools which cannot be definitely identified as such, because of the absence of a calf or calves to betray the presence of females among the smaller whales present. It should be added that when harem schools and nursery schools are identified at sea, it is not thereby inferred that all the small whales (less than 11.7 m) present are females, because the examination of catches from such schools has shown that immature and puberal males may also be present (R. Clarke, 1956, p. 279 ; Caldwell, Caldwell and Rice, 1966 ; Best, 1970b).

Sperm whale schools were classified in this way during the surveys off Chile

TABLE 6. FREQUENCIES OF THE SIZES OF SCHOOLS OF WHALES SIGHTED OFF THE COAST OF CHILE IN 1964. IN THIS TABLE SOLITARY WHALES ARE ALSO INCLUDED, AS ' SCHOOLS OF ONE '

Nos of whales in a school	Blue	Fin	Sei	Sperm	Black-fish	Bottle-nose	Unidentified small whales	Dolphins	Porpoises
1	2	1	1	8		2	3		
2	1			7	1		1		
3				3	2		2		
4				1					
5				2					
6				2				1	1
6–8								1	
8				6	2			1	
9				1					
8–10								1	
10					1				
11				1					
12									
14							1		
15–20							1		1
20				1	1				2
22					1				
28				1					
30				1					
30–40					1				
35–40					1				
40–50					1				
50–60									1
Total schools	3	1	1	34	11	2	8	4	5
Total whales	4	1	1	203*	194	2	43	30	119
Av. nos per school	(1.3)	(1)	(1)	6.0	17.6	(1)	5.4	7.5	23.8
Av. nos per school in 1958	—	2.6	—	1.4	22.9	(5)	—	18.8	—

* In the concentration of 90–110 Sperm whales on 30 November, the count from the sizes of schools at a certain moment came to 94, which explains the apparent discrepancy between the total for all sperm whales given here (203) and that in Table 3 (199–219, average 209).

in 1958 (R. Clarke, 1962, Table 2) and in 1964 (Table 7). When numbers of sperm whales are sighted at a particular position they may, depending upon latitude and season, comprise schools of some or all of the observable classes scattered over a wide area ; thus, the great concentration of 90–110 whales sighted on 30 November 1964 comprised solitary whales, bachelor schools, harem schools, nursery schools and unclassified schools dispersed over 15 square miles of sea (Table 1). Such concentrations are not to be confused with the *herds* which are occasionally encountered at sea (Bennett, 1840, vol. II, p. 171 ; R. Clarke, 1956, p. 279) ; the sperm whale herd is formed only when the animals are migrating, and consists of schools which have come together as a tight body of whales, one hundred to several hundred strong, all travelling in the same direction. No herds were seen in 1958 or 1964. Schools of sperm whales may not remain stable when approached for observation and marking. Solitary males, several hundred yards apart when first sighted, may subsequently school together or join existing schools ; nursery schools may also join together and separate again in schools of different size, and so may unclassified schools : but harem schools appear to be more stable, as might be expected from such breeding groups (Table 7).

Immigration. Table 6 shows the frequencies of the sizes of schools, including those of solitary whales as ' schools of one '. Using this classification sperm whale schools off Chile in November-December 1964 were on average more than four times larger (6.0 whales per school) than in October-November 1958 (1.4 whales per school). This is because relatively few solitary males were seen in 1964 (3.9% of all sperm whales observed) compared with those seen in 1958 when they comprised 56% of the total. R. Clarke (1962), noting this result that 56% of sperm whales were solitary off Chile in October-November 1958, whereas only 4% were solitary at the same time of the year in a survey conducted from the coast of Ecuador to the Galápagos Islands in 1959, suggested that with increasing latitude the female stock thins out and the males increasingly adopt the solitary habit ; but the present results indicate that this was too broad a generalisation which did not sufficiently take account of seasonal changes in the spread of schools and in the pattern of schooling.

The sperm whale schools seen in 1964 included numbers of females, females with calves, and young whales of either sex, as shown by the harem schools, nursery schools and unidentified schools recorded in Table 7. In five instances where these schools appeared to be travelling in a definite direction, the movement of four schools was southwest and of one east. Two bachelor schools were also seen travelling south, and in the class of solitary males, one was moving south, another southwest and one east. None of these whales were among those large numbers seen on 30 November 1964 close to the chain of islands north of Coquimbo (Fig. 1, Table 1), for here no steady direction of movement could be discerned for any of them (which included the large concentration of 90–110) and all were confidently believed to be feeding. But it may be said that, where whales were travelling, their movement was predominantly southerly. On the other hand no direction predominated in the sperm whales observed on the same track in October-Novem-

TABLE 7. CLASSIFICATION OF THE SCHOOLS OF SPERM WHALES SIGHTED IN 1964

Classification	Date and Time	Position	Surface Temp. °C	Nos of whales	Schooling	Direction	Remarks
Solitary males:	28. xi/1830	29°16′S, 71°47′W	15.0°	1		S	A solitary from the sighting of 16 sperm whales, Pl. I, Fig. 1.
	29. xi/0705	29°03′S, 71°48′W	15.5°	2	Separate	SW	Small males 9–10.5 m (30–35 ft) } From the sighting of 33 sperm whales
	— /0815	29°05′S, 71°48′W	15.5°	1			Small male about 9.8 m (32 ft) } From the sighting of 33 sperm whales
	30. xi/1345	29°35′S, 71°38′W	18.3°	2	Separate		Small males, from the sighting of 26 whales
	— /1510	29°38′S, 71°38′W	18.7°	1			Large bull which sounded for 45 minutes when chased and had not emerged when the chase was abandoned. From the sighting of 26 whales
	9. xii/1500	35°17′S, 74°29′W	17.1°	1		E	Large bull about 17.3 m (57 ft)
	— /1550	35°17′S, 74°33′W	17.0°	1			Large bull
Bachelor schools:	28. xi/1830	29°16′S, 71°47′W	15.0°	5	One of 3	S	} From the sighting of 16 sperm whales
					Pair	S	
	29. xi/0815	29°05′S, 71°48′W	15.5°	2	Pair		From the sighting of 33 sperm whales
Harem schools:	29. xi/0705	29°03′S, 71°48′W	15.5°	10	one of 4	SW	School comprised one male (11.6–12.2 m, 38–40 ft), one female (10.7–11.6 m, 35–38 ft) with calf (5.5 m, 18 ft) and another whale presumably female, of 10.7–11.6 m (35–38 ft).
					One of 6	SW	Pl. I, Fig. 2.
	— /0815	29°05′S, 71°48′W	15.5°	9	One of 9		School included two calves, each about 6 m (20 ft). The three harem schools above were from the sighting of 33 sperm whales.
	30. xi 1610–1915	29°40′S, 71°36′W to 29°45′S, 71°39′W	18.1° to 18.7°	—	—		Harem schools were present in the concentration of 90–110 sperm whales.
Nursery schools:	30. xi/1345	29°35′S, 71°38′W	18.3°	16	Two of 8		One school comprised two calves each 5.5–6.1 m (18–20 ft), swimming on either side of a female of 11 m (36 ft), another whale of 11 m, and then four whales of 9 m (30 ft).

	— /1510	29°38′S, 71°38′W	18.7°	5	One of 5		School comprised two females, each 9.8 m (32 ft) with their calves of 5.5 m (18 ft), and with another whale of 9.8 m.
	— /1345	29°35′S, 71°38′W	18.3°	2	One of 2		Mother and calf (Pl. II, Fig. 1) The three nursery schools and the mother and calf above were from the sighting of 26 sperm whales.
	30. xi 1610–1915	29°40′S, 71°36′W to 29°45′S, 71°39′W	18.1° to 18.7°	—	—		Nursery schools were present in the concentration of 90–110 sperm whales
Unclassified schools:	28. xi/1830	29°16′S, 71°47′W	15.0	10	Two of 5	SW	Each school with at least two males, about 13.5 m (45 ft), and the remaining whales of 10.5–12 m (35–40 ft). They could have been bachelor schools or harems. From the sighting of 16 sperm whales.
	29. xi/0705	29°03′S, 71°48′W	15.5°	6	Three pairs	SW	All about 9–10.5 m (30–35 ft). May have been bachelor pairs.
	— /0815	29°05′S, 71°48′W	15.5°	3	One of three		This school and the three pairs above were from the sighting of 33 sperm whales.
	— /1645	28°00′S, 71°58′W	18.2°	2	Pair	E	Probably a bachelor pair, but no sizes were recorded.
	30. xi 0715–1020	29°00′S, 71°43′W to 29°02′S, 71°39′W	14.8° to 16.0°	30	11, 8, 8, 3		In this sighting of 30 whales, all were animals of medium or small size, being not more than 40 feet. At first 6 separate whales (males) were sighted, all within a few hundred yards of each other, apparently scattered for feeding. More whales appeared, and the individuals joined schools which broke and reformed. At one time there were four schools of 11, 8, 8, 3. Possibly all were batchelor schools.
	30. xi 1610–1915	29°40′S, 71°36′W to 29°45′S, 71°39′W	18.1° to 18.7°	—	—		Unclassified schools were present in the concentration of 90–110 sperm whales.

ber 1958, and R. Clarke (1962) concluded that there was nothing to suggest that they were migrating.

Townsend (1935) published world charts showing the positions month by month of captures of sperm whales recorded in the log-books of the sailing whaleships between 1761 and 1920. In equatorial latitudes of the Pacific sperm whales were taken at all times of the year, and, as R. Clarke (1962) has observed, the charts show also an abundance of sperm whales off Peru and Chile, with indications of a spread southward in summer. With the evidence of these charts in mind, the differences observed in this region off Chile in 1964 compared with 1958—larger schools and fewer solitary males, more females and calves and young whales, and a general southerly movement of the whales not actively feeding—all indicate an influx of sperm whales from the north over the period between October-November (of 1958) and November-December (of 1964). This influx would represent a spread southward in early summer of some part of the breeding stock.

Observations of sperm whales off the west coast of South Africa suggests that 'large bulls over 45 ft (13.5 m) in length join the female schools for the main breeding season' (Best, 1969a). In the Southeast Pacific the main pairing season has been estimated to last from June to December with a peak in September (R. Clarke, Aguayo and Paliza, 1964). During the expedition off Chile in 1958, most of the 15 solitary male sperm whales sighted (R. Clarke, 1962, Table 3) were large individuals: Clarke's unpublished records show that, of six solitary males whose lengths were estimated, five were between 48 ft (14.6 m) and 52 ft (15.9 m) long. It is therefore possible that the large solitary males, which formed the majority of the sperm whales sighted in these latitudes off Chile in October-November (of 1958) had by November-December (of 1964) either schooled as harem males with arriving females, or, failing to secure harems, had schooled with other bachelors ; or perhaps they had moved further south on the way to spend the summer in the Antarctic. However, since the peak of conceptions is in September, most of the pairing may be considered to have taken place to the north of the area surveyed. On the other hand, parturition in Southeast Pacific sperm whales extends mainly from November to May, with a peak in February (R. Clarke, Aguayo and Paliza, 1964), and we believe that the results from material now being analysed will confirm our impression that this area between 28° and 36°S, especially in its southern part, is a calving ground for the breeding stock which begins to accumulate there, as the observations from 1958 and 1964 now show, during November and December. (There is evidence that elsewhere sperm whale calving grounds are in similar warm temperate latitudes, as the Azores around 38°N (R. Clarke, 1956) and South African seas off Durban in 30°S (Gambell, 1967) and off Saldanha Bay in 33°S (Best, 1969b) ; whilst Pervushin (1966) and Gambell, Lockyer and Ross (1973) have actually observed sperm whales calving, respectively in March in 37°01′S, 71°44′E and in February in 33°49′S, 28°02′E). Of the calves seen in harems and nursery schools during the expedition of 1964 there were seven whose estimated lengths were recorded (Table 7) ; they ranged from 5.5 m (18 ft) to 6.1 m (20 ft), so that none were newborn nor young-of-the-year, for the length of the sperm whale

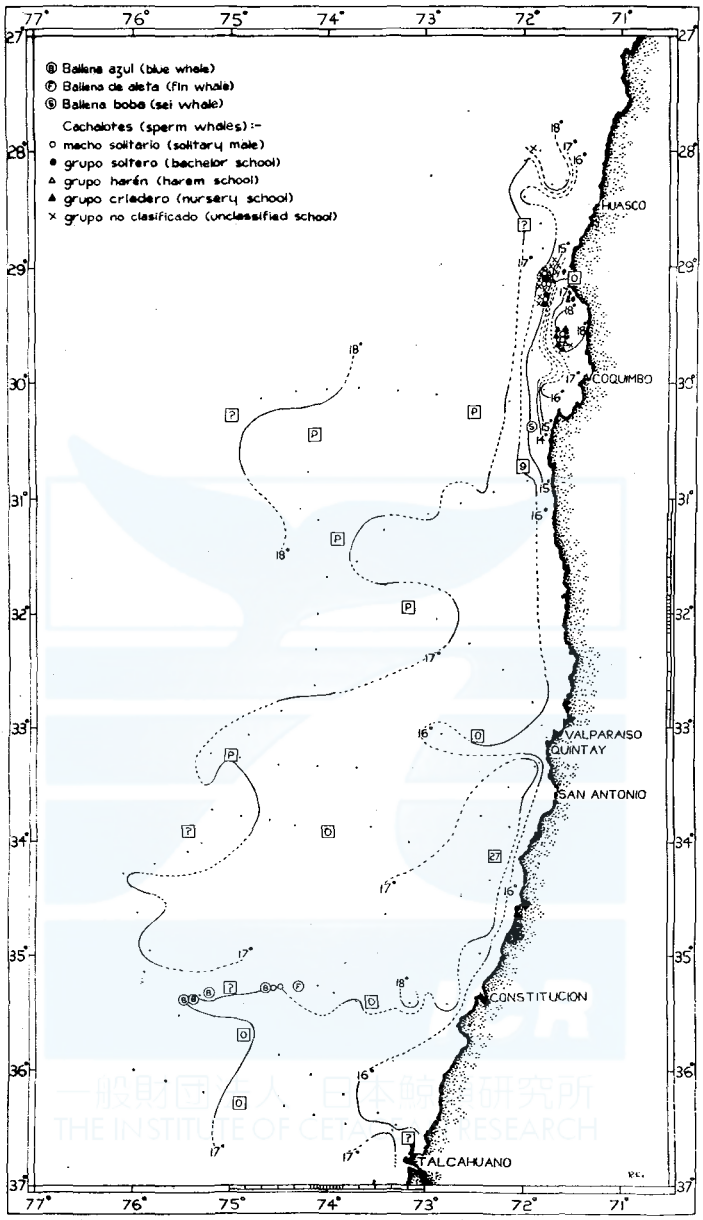

Fig. 3. Surface isotherms during the voyage of *Indus XIV* off the coast of Chile between 24 November and 17 December 1964. There are plotted the sightings of the larger whales; and (in square boxes) the numbers of strikes and/or captures per hour of the Humboldt Current squid *Dosidicus gigas* during the oceanographical stations.

neonate in the Southeast Pacific has been estimated by R. Clarke, Aguayo and Paliza (1964) at 4.02 m (13 ft 2 in): they will have been young of a previous calving season, because lactation is protracted in the sperm whale and the calf is weaned, at least in the North Atlantic, when about 6.7 m (22 ft) in length (R. Clarke, 1956, p. 275). Since the peak of the calving season is in February, it was not to be expected that we should see any number of newborn calves in the voyage of November-December 1964.

We have dealt here with immigration of sperm whales into the area surveyed. On p. 156 we record direct evidence from whale marking of the migration of male sperm whales from this area into the Antarctic.

Distribution and water temperature. In his report on the surveys conducted off Chile in 1958 and from Ecuador towards and beyond the Galápagos Islands in 1959, R. Clarke (1962) wrote:

'Female sperm whales do not range beyond about 40° North and South (Matthews, 1938, p. 160), apparently because they avoid cold water, so it would be expected that a similar exclusion might be traced, meridionally rather than latitudinally, in an upwelling region like the Humboldt Current where typically the water is coldest near to the coast and becomes progressively warmer towards the oceanic boundary. Schubert (1951, 1955), from observations made in pelagic factory ships whaling on the coasts of Peru and Chile in 1938 and 1951 (including the latitudes explored by *Indus X* in 1958) concluded that there was an orderly segregation from the coast westward of solitary males in water of 15°–17°C, bachelor schools in water of 16°–18°C, and female schools in water of 17°C and warmer. Temperature observations on the two expeditions discussed here, so far as they go (Table 2), only partly support Schubert's conclusions.'

Further data on the distribution of sperm whales and water temperature were collected on the expedition off Chile in 1964. Table 7 includes the surface temperatures observed at the positions where the various classes of sperm whales were sighted. In Fig. 3 the whales sighted are plotted according to their classes on a chart of the surface isotherms prepared from the two-hourly temperature observations made throughout the expedition.

The surface isotherms are of interest in themselves as showing two regions of active upwelling in this area of the Humboldt Current during the period of the expedition: thus, the isotherms run close together and parallel to the coast from south of Quintay to Constitución (about 33°20′S to 35°20′S), where in fact no sperm whales were seen during the survey; and from south of Huasco to south of Coquimbo (28°40′S to 30°40′S), where nearly all the sperm whales were seen. In this latter upwelling region the 14°C isotherm runs more or less north and south to westward of the chain of islands between Is. Chañaral and Is. Pájaros, with increasing temperatures to either side, indicating an inshore eddy of comparatively warm water (rising to 19°C) which embraces the islands and extends to the mainland coast. The great concentration of 90–110 sperm whales, first sighted three miles from Is. Pájaros on 30 November, was within this eddy at temperatures of 18.1° to 18.7°C (Table 1). This concentration comprised harem schools, nursery

schools and unidentified schools, and also a few solitary young bachelors which eventually schooled.

In Table 8 the records on surface temperatures and the classes of schools from Table 7 are presented with those from the previous expedition off Chile in 1958, and the expedition from the coast of Ecuador to the Galápagos Is. in 1959. Figure 3 and Table 8 do not support Schubert's conclusions which we are therefore unable to accept. Solitary males have been observed in water as warm as 22.6°C, and nor is it credible that this class of sperm whale, which is widespread in all seas from the equator to the polar ice, should confine itself to relatively cold water. Females in harem schools have been observed in water as cold as 14°C. That bachelor schools were observed only in the small range of 15.0–15.5°C we consider an accident due to the paucity of data for this class, for bachelor schools were observed, though not recorded in detail and therefore not included in Table 8, in the great concentration off Is. Pájaros in water of 18.1° to 18.7°C.

TABLE 8. THE CLASSES OF SPERM WHALE SCHOOLS AND SURFACE TEMPERATURE. FROM THREE VOYAGES IN THE SOUTHEAST PACIFIC.

Classification of schools	1964		1958 (Clarke, 1962, Table 2)		Ecuador to Galápagos Is. 1959 (Clarke, 1962, Table 2)		Summary	
	No. of whales	Temp °C	No. of whales	Temp °C	No. of whales	Temp °C	No. of whales	Temp °C
Solitary males	9	15.0–18.7	15	13.6–15.3	5	21.4–22.6	29	13.6–22.6
Bachelor schools	7	15.0–15.5	3	15.3			10	15.0–15.5
Harem schools	19+	15.5–18.7	5	14.0			24+	14.0–18.7
Nursery schools	23+	18.1–18.7			80–100	17.9	103–123+	17.9–18.7
Unclassified schools	51+	14.8–18.7					51+	14.8–18.7

However, Table 8 does suggest that nursery schools are limited to water not colder than 17.9°C, say 18°C. We may reasonably believe that this is because of the thermal requirements of the calves. Even so, the limitation is not a rigorous one, for the nursery schools in the concentration off Is. Pájaros in 1964 will have needed to cross water of 14°C to enter the warm eddy, and indeed, two of the harem schools observed in water of 15.5°C on 29 November included calves (Table 7). But it is noteworthy that both these harem schools were travelling, not lingering nor feeding, and the suggestion is that females with their calves seek out water of 18°C or more, although in the seeking the calves may tolerate colder water. It may be that the nursery school, a grouping of small whales, females and calves, becomes an expedient in upwelling regions to serve the requirements of the mother for food and the calf for warmth: we may imagine that the calves are ' parked ' in the nursery schools in warm water, as for instance the eddy off Is. Pájaros, whilst some of the mothers go off to feed in the adjacent upwelling stream, perhaps leaving their calves in the care of ' aunties ' such as exist in some other animal communities.

Observations elsewhere have also demonstrated that female sperm whales are tolerant of colder water than has been claimed by Schubert, and later by Gilmore (1959) and Radovich (1961) who gave limits of 20°C and 17°C respectively. Actually the limits of tolerance must not be those of the mother whales and other adult females, but rather those of the accompanying calves and juveniles whose thermal requirements are one of the factors which limit their diving range, because, as Gaskin and Cawthorn (1967) have noted, adult sperm whales of both sexes may be in comparatively warm water at the surface and quickly find themselves in water near freezing when diving for food at depth.

When Pervushin (1966) observed sperm whales calving, the surface temperature was 17.5°C. Females in the North Pacific are occasionally taken as far north as the Aleutian Islands in 52°N when the summer temperature of the sea is above the normal of 13°C (Nishiwaki, 1966a). This agrees with the lowest surface temperature, 14°C, at which (in 1958) harem schools were seen in the Southeast Pacific, although in another paper Nishiwaki (1966b) says that in the North Pacific females may enter seas as cold as 10°C, but not colder. However, he makes no mention in either paper of calves accompanying the females. Earlier, Matsuura (1935) had even recorded harem schools sometimes entering water as cold as 3°–10°C off Japan, again without mention of calves, although Berzin (1971, p. 182) refers to Russian observations of females with calves at temperatures below 3°–10°C in the Sea of Okhotsk and off the Kurile Islands. In the western South Pacific Gaskin (1971) records a harem school (in Cook Strait) in water about 10°–12°C as an abnormal occurrence, and gives records of 14°–16°C as realistic limiting temperatures for nursery schools; regarding latitude, Gaskin (1973) mentions an extreme record of a female taken in 54°55'S, but puts the normal limits at 50°S in the western South Pacific. Thus, although the statement that female sperm whales do not range beyond 40° North and South holds good as a generalisation, the limit in the southern hemisphere has been put more precisely in oceanographical terms by Bannister (1968) and Best (1976) as the subtropical convergence. This lies for the most part around 40°S but in places extends nearly to 50°S, whilst 'the water just north of the convergence has a temperature of at least 11.5°C in winter and 14.5°C in summer' (Deacon, 1937, Fig. 4 and p. 72): these ranges just about encompass the latitudinal and temperature limits for female sperm whales reviewed here, save for those mentioned by Matsuura and Berzin.

Distribution and the squid Dosidicus gigas. Sperm whales of the Southeast Pacific, like those in most other parts of the world, feed mainly upon squid.

R. Clarke (1962), referring to the great numbers of large squid seen at the surface at night during the expeditions off the coast of Chile in 1958 and from Ecuador to the Galápagos Islands in 1959, observed that the specimens collected seemed to be identical with the common Humboldt Current squid *Dosidicus* (*Ommastrephes*) *gigas*. Now in other oceans, ommastrephids with a similar habit, abounding at the surface, are not known to be eaten by the sperm whale, or are rarely eaten. Drawing attention to this interesting circumstance, R. Clarke emphasised nonetheless the possibility that sperm whales of the Southeast Pacific

might in the event be found to be feeding on *D. gigas*, when study of the biology and distribution of this squid would become important to the whale investigations.

Recently M. R. Clarke, MacLeod and Paliza (1976) have reported on cephalopod remains from the stomachs of sperm whales examined in Chile and Peru. They have not only established the presence of beaks of *D. gigas* in stomachs from Paita and Pisco in Peru, but have also estimated that, although this large bulky species only constituted 3.6% of the total number of beaks in the samples, it contributed 31.6% of the squid flesh swallowed by the whales. It appears therefore that in the Southeast Pacific *D. gigas* is one of the most important species of squid in the nutrition of sperm whales.

The identification of *D. gigas* beaks in the stomach contents was made by Dr. Malcolm Clarke as early as 1963, when the samples were sent to the National Institute of Oceanography in England (see R. Clarke, Aguayo and Paliza, 1968, Part I.). Consequently, during the expedition off Chile in 1964 we arranged to fish for squids each night when the ship lay drifting, so as to look for any correlation between our sightings of sperm whales and the distribution and abundance of the squids. It is with these results that we are here concerned: an account of the fishing methods and some observations on the squid themselves are included in ' Other work on the voyage ', p. 162.

Fishing was conducted mostly at 25 or 50 m. All the squids we caught were the same species, and the fourteen specimens preserved were later identified as *D. gigas* by Mr. Patricio García-Tello (p. 163). This makes us confident that the large squid we saw around the ship, and the ' strikes ' not captured were all *D. gigas*. In Fig. 3 the numbers in square boxes represent the abundance of the squid as the number of strikes and/or captures per hour's fishing (Table 10) at each of the Stations I_{14} to I_{31} (Fig. 1). The letter ' P ' within a box indicates those stations where no strikes or captures were made during the routine fishing period, but squid were known to be present, either because they were seen at the surface or because they were caught at some time in the night by the watch after the station work had been completed. At five of the stations, for one reason or another (Table 10) no fishing was undertaken, and here a question mark appears in the box.

We had expected a correlation between the presence of numerous sperm whales, an abundance of *D. gigas*, and positions of active upwelling, but the results supported no such correlation. The greatest abundance of squids, yielding 27 squids per hour's fishing, were at station I_{24} in the region of active upwelling south of San Antonio, but no sperm whales were observed there ; nor were sperm whales observed at station I_{17} where squids were also abundant (nine per hour's fishing) in the southern part of the active upwelling in the Coquimbo area. On the other hand no squids were caught at station I_{18} in the northern part of this upwelling region, although sperm whales were abundant at and near station I_{18}; actually *D. gigas* is so abundant in this region of the chain of islands north of Coquimbo that the only factory for making squid meal in Chile is working here on the mainland coast (García-Tello, 1965). Figure 3 also shows that squids were present further westward in water of surface temperature between 17° and 18°C where

no sperm whales were seen. There are several possible reasons for these unexpected results: the stations were comparatively few; the total fishing time at any station was usually 30 minutes or less, and never more than one hour; and although various baits of fish and meat were used, we might have done better with no bait at all, for the best catch (at Station I_{24}) was taken with an unbaited *tota* (see p. 163): or perhaps there was no correlation possible because the whales were feeding mostly in the day when the *D. gigas* were at a deeper level and displaced horizontally from our stations.

We have thought it worthwhile to report these results because, although routine observations and exploratory fishing for oceanic surface-living squid have been conducted before (Baker, 1960), this is the first time to our knowledge that observations on sperm whales have been combined with exploratory fishing for a squid known to be a constituent of the diet. It is hoped that more work of this kind will be done on future voyages in the Southeast Pacific. The fishing methods need to be improved by experiment, and then standardised and conducted more intensely. Fishing seems at present to be the most reliable way to measure abundance of these squids, because (as Baker (1960) has observed in regard to *Ommastrephes pteropus*) the squids move in and out of the illuminated area around the ship so quickly that they cannot be counted; also the fact that no squid may be seen at the surface is no guarantee that they are not present twenty or so metres down.

It is not surprising that *D. gigas*, because of its size and abundance, should be eaten by sperm whales in the Southeast Pacific: it is surprising that related squids of similar habit in other oceans should be eaten rarely or not at all. Betesheva and Akimushkin (1955) claimed that in the North Pacific *Ommastrephes sloanei pacificus* is only rarely eaten, a statement later modified by Akimushkin who said (1963, p. 196) that it is not eaten. The squid abundant at the surface in the North Atlantic, *Ommastrephes pteropus*, is not known to be eaten by the sperm whale (Baker, 1957; M. R. Clarke, 1962), although M. R. Clarke (1966, p. 105) says that specimens of *Ommastrephes* discussed by Baker (1957, 1960) included not only *O. pteropus* but also *O. caroli* and possibly *O. bartrami* which Kawakami (1976) has now recorded from the stomachs of sperm whales in the Northwest Pacific. Dr. Malcolm Clarke has informed us that the surface living squid of the Indian Ocean, *Symplectoteuthis oualaniensis* has not be recorded from sperm whales in that ocean, although some of the beaks examined from sperm whales at Paita, Peru are believed to belong to this species (M. R. Clarke, MacLeod and Paliza, 1976). It is not clear why sperm whales outside the Southeast Pacific should pay little or no attention to the surface frequenting ommastrephids. Betesheva and Akimushkin (1955) and Berzin (1971, p. 201) believe that *O. sloanei pacificus* is confined to the surface and that sperm whales feed at deeper levels; yet *O. pteropus* has been recorded from the surface to depths as great as 1,000 m (Baker, 1960), and we believe—from the accumulating evidence on the food of sperm whales in various seas—that these whales are feeding at all levels from the surface to substantial depths. Again, *S. oualaniensis* and *D. gigas* have light organs (Roper, 1963; M. R. Clarke, 1965) and *D. gigas* has

been observed to emit a brilliant blue light (García-Tello, 1964), so it might be thought that in these squids the light betrays the squid to the sperm whale; but *O. pteropus* is also bioluminescent (Roper, 1963; M. R. Clarke, 1965) and is not known to be eaten.

Blackfish (Globicephala melaena edwardi)

Results on the distribution and abundance of blackfish off Chile need to be prefaced with remarks on the species identification. As R. Clarke (1962) has observed, these blackfish in the parochial sense ' are to be referred to *Globicephala chilensis* which Philippi (1896) described as a new species from two almost complete skeletons cast up on the coast of Chile '. On three occasions some of the blackfish sighted in the expedition of 1964 (Table 1) were approached closely enough to observe the pigmentation. These bore a whitish saddle-shaped area behind the dorsal fin (Pl. II, Fig. 2) and a whitish streak behind the eye. In one large school of 40–50 whales sighted at 1905 on 1 December, one adult of about 4.6 m. (15 ft) was posed upright in the water, apparently watching the vessel, and it was seen to have a white patch on the throat. The saddle-shaped white area behind the dorsal fin and the whitish steak behind the eye are the distinctive external characters which Rayner (1939) used to describe the southern blackfish, *G. leucosagmaphora*. According to F. C. Fraser, in Ellermann, Morrison-Scott and Hayman (1953), *leucosagmaphora* is antedated by *edwardi* A. Smith, 1834. R. Clarke (1962), discussing the blackfish sighted off Chile in 1958, noted that ' Davies (1960) believed that differences between the northern and southern forms did not warrant more than subspecific importance at most, and so he distinguished a northern *G. melaena melaena* from a southern *G. melaena edwardi*. He drew attention to records of southern *Globicephala* which apparently lacked the dorsal white saddle, and to a record of northern *G. melaena* which possessed the saddle, and explained that he and other authors found no differences between the skulls of *Globicephala* from Tasmania, the Falkland Islands, the Cape of Good Hope and Kerguelen'. Davies' proposal has since been accepted by Sergeant (1962a), who has made an intensive study of the North Atlantic blackfish, and by Rice and Scheffer (1968) in their classification of marine mammals: Hershkovitz (1966, p. 96) lumps the southern and northern forms together, saying that distinctions are based on ' individual or pod variables ' and are without geographical basis, but this would seem to us to go too far whilst so little anatomical material has been examined from great areas like the Southeast Pacific. R. Clarke was content to leave the blackfish sighted off Chile in 1958 (and also off the coast of Ecuador in 1959) as *Globicephala* sp., because he had been able to observe only the white saddle and not the whitish streak behind the eye described by Rayner, and also because True (1903) considered that Philippi's *G. chilensis* could be distinguished by characters in the skull and backbone from *G. melas* (*melaena*). But now that we have observed the white streak behind the eye, and also the white throat which agrees with Rayner's description of *leucosagmaphora* as being similar in its ventral white pigmentation to *melaena*, it appears reasonable to identify the blackfish of the Southeast Pacific as *G. melaena*

edwardi. However, the identification is tentative only, for it is based upon the pigmentation of the body which certainly seems to vary a good deal in *Globicephala*. The matter will not be settled until specimens of blackfish from the west coast of South America are examined anatomically and osteologically, when the differences claimed by True can be confirmed or denied. Meanwhile, if records of blackfish in the Southeast Pacific all refer to *G. melaena edwardi*, its range is continuous from the south of Chile (Cabrera and Yepes, 1940, p. 300, Tierra del Fuego ; Norris, cited by Aguayo, 1975, Golfo de Penas ; Philippi, 1893, 1896, Isla Chiloé ; Aguayo, 1975, the region from 49° to 33°S ; Gilmore, 1971, Isla Mocha) through central Chile (Philippi, 1893, 1896, Los Vilos ; Oliver, 1946, Concepción ; R. Clarke, 1962 ; the present paper) and far out at sea near Isla San Ambrosio off northern Chile (Gilmore, 1971) to the length of the coast of Peru (Scammon, 1874, p. 87 ; R. Clarke, 1962 ; Guillen and Flores, 1965 ; Mejia and Poma, 1966 ; Aguayo, 1975) and the coast of Ecuador (Scammon, 1874, p. 87 ; R. Clarke, 1962 ; Leveque, 1963).

During the expedition off Chile in 1964 there were seen 181–206 blackfish, all of them in the track of 1958, for none were sighted on the extension southwards to Talcahuano. They were sighted on eleven occasions (Table 1), and the general distribution of these sightings across the body of the Humboldt Current, from 20 to as much as 160 nautical miles from the coast, was similar to the distribution of 1958 (Figs 1 and 2). In 1964 the abundance of blackfish as numbers per 100 nautical miles sailed (Table 3) was very similar to the abundance in 1958 (respectively 11.0 and 13.2 per 100 nautical miles sailed) ; the abundance measured in this gregarious species as sightings per 100 nautical miles sailed (Table 4) was just about the same in 1964 and 1958 (0.63 and 0.70 per 100 nautical miles sailed), as were the number of whales per sighting (17.6 and 18.7). The stock of blackfish off Chile is not exploited at present, and the numbers are therefore likely to remain steady from year to year, so that these results from two surveys over the same track at very nearly the same time of the year were to be expected ; we have earlier noted (p. 127) that to have obtained these expected results makes us confident that our results for the abundance of other whales may be significantly compared.

In 1964 the direction of movement of the blackfish was noted at seven sightings (Table 1) ; the directions were south or southerly on four occasions, and west, east and northeast on the others, suggesting, as far as they go, that the general trend of movement might be southerly. The sizes of schools are shown in Table 6 : the average numbers per school were 17.6 in 1964 and 22.9 in 1958, when the average was somewhat swelled by one sighting of a school of about 100 whales (R. Clarke, 1962, Table 3) ; these figures agree well with the sizes of schools in the North Atlantic where Sergeant (1962b) says ' the pelagic herds comprise on average about 20 individuals and rarely include more than 100, . . . '. In Table 1 there are some notes on the estimated sizes of the blackfish we encountered ; they include one whale, which from its size must have been a male, estimated at 7.5 m (25 ft). This was probably an over-estimate, for the largest of 1,275 males measured in the North Atlantic was 6.17 m or 20.2 ft (Sergeant, 1962b) ; however, it is possible

that blackfish grow bigger in the southern hemisphere for few southern blackfish have been measured, the largest, 5.89 m (19.3 ft), being from a sample of ten males belonging to a school stranded in Tasmania (Scott, 1942).

Blackfish sometimes mingle with other cetaceans. This was observed in two of the eleven encounters with blackfish in 1964 ; on one occasion a school of 30–40 was accompanied by eight dolphins (see p. 151), and on another a school of ten accompanied 6–8 dolphins and a fin whale (Table 1). In 1958 they were seen to be mingled with other cetaceans on four occasions, respectively with sperm whales, fin whales (twice) and a fin whale with dolphins (R. Clarke, 1962). Gilmore (1971) and Aguayo (1975) have also reported them mingled with bottlenosed dolphins (*Tursiops* sp.) off Isla San Ambrosio in Chilean seas. In other seas their association with sperm whales have been reported by Gaskin and Cawthorn (1967), and with dolphins and porpoises by Sergeant and Fisher (1957), Norris and Prescott (1961), Brown (1961b), Fiscus and Niggol (1965) and Pilleri and Knuckey (1968, 1969). As Gilmore (1971) has noted, the habit of the blackfish of mingling with other cetaceans is widespread and appears to be characteristic of *Globicephala.*

From the results of the expeditions of 1958 and 1964 we recommend that consideration should be given to exploiting the blackfish resource off the coast of Chile (see also Aguayo, 1975). At the present time blackfish are hunted in Norway, the Faeroe Islands, Greenland, Newfoundland, the Lesser Antilles and Japan. The *International Whaling Statistics* (1976, LXXVII, Table Z5) give the catches from these countries (except the Lesser Antilles) between 1964 and 1968. In the Faeroe Islands and Newfoundland the whales are driven ashore (Williamson, 1945 ; Sergeant, 1962b). At St. Vincent in the Lesser Antilles of the Caribbean, there is a hand harpoon fishery from open boats (Mitchell, 1975, p. 82). In Japan and Norway they contribute with other cetacean species to the ' small whale ' catch taken pelagically by small vessels using the harpoon gun, as described by Omura, Maeda and Miyazaki (1953), Jonsgård (1955) and Foote (1975). Similar small whalecatchers would be required in Chile, where the schools of blackfish do not (so far as we are aware) come close enough to the coast to be driven ashore. Blackfish meat is edible : in Japan and the Faeroe Islands it is used for human consumption, and in Norway and Newfoundland it is used for animal food, including food for mink and fox farms. If blackfish whaling is started in Chile, then from the beginning there should be established a research programme to monitor continuously the stock under exploitation.

Bottlenosed whales

There were two occasions on the expedition of 1964 when Captain Parra sighted a solitary whale which he reported as a bottlenosed whale (Table 1, Fig. 1). Little is known of the true southern bottlenosed whale, *Hyperoodon planifrons,* of which there are only twenty records of flesh or bone at the present time (Gianuca and Castello, 1976). A number of sighting records have been published, but nearly all of these are unreliable, because the species can easily be confused at sea with certain other ziphioid whales. Therefore we cannot be sure that the two whales

reported by Captain Parra were definitely *H. planifrons*, although they may well have been, since R. Clarke (1962) recorded five *H. planifrons* in 33°15'S, 73°27'W on the expedition of 1958. We accept Robert Clarke's identification because during the Antarctic whaling season of 1947–48 he arranged for a specimen of *H. planifrons* to be shot, and combined a complete examination of the specimen with his photographs and observations of the living whale (see Fraser, 1964); but on the expedition off Chile in 1964 he was not on deck to confirm Captain Parra's sighting.

There are other reports from Chilean seas of whales believed by the observers to be *H. planifrons*. Two were reported in Drake Strait in December 1965 (Aguayo and Torres, 1967), and in 1966 there were reported 14 animals in March-April and six in December, and in 1973 a solitary animal in February (Aguayo, *unpublished*). Duguy (1973) also saw two whales in Drake Strait in December 1972 which he thought were probably *H. planifrons*. There is one report which we do not accept even as a possibility: Gianuca and Castello (1976) said 'Morzer Bruyns (1971) saw a pod off Chile estimated to comprise about 40 specimens (May, 1965)'; actually Bruyns (1971, p. 149) saw only records where an unidentified observer had reported 40 pilot whales (blackfish) but which Bruyns, solely from notes on their pigmentation, thought 'must have been' the southern bottlenosed whale.

Unidentified small whales

There were eight sightings in 1964 of small whales which we could not identify (Table 1). On most occasions they were too far away, and there is nothing more to be said about them, but we are here concerned with two sightings, at 1755 on 24 November and at 0712 on 27 November, of a species of whales which we have never seen before.

On both occasions the schools were chased for observation, the first time for 35 minutes and the second time for nearly three hours, when an unsuccessful attempt was made to harpoon a specimen. Photographs were taken but we could not approach them closely. When chased they soon became scared and ran fast, keeping their distance from the ship steaming at 13 knots. Each time the school stayed together during the chase, and on the first occasion the school was noted as running in single line abreast. The first sighting was a school of 15–20, the whales being about 6.0 m (20 ft) long; the second sighting comprised a school of 14, all about 4.5–6.0 m (15–20 ft) long. Some of the external characters are shown in Pl. III, Fig. 1. The head was somewhat bulged, and we caught a glimpse of the snout of one individual: it was bluntly rounded, without any sign of a beak. The dorsal fin was conspicuously high, rising stoutly from a wide base, with the axis inclined slightly backward; the anterior margin was steep, with scarcely any curve until it swept back to form the blunt tip; the posterior margin was shallowly concave. The whales did not at any time show more of the body surface above the water than the midline of the flanks, so nothing can be said of the ventral colouration. The back posterior to the dorsal fin was dark, almost black. The forepart of the body was greyish-white of a streaky pattern, extending in some individuals

from the head to the anterior emargination of the dorsal fin, and in others from the head to the region just behind the dorsal fin which thus appeared to rise up like a dark island in a white surround. The dorsal fin itself was generally dark, although streaks of white invaded the base in varying amounts, and one whale had the length of the anterior margin of the fin white, and the remainder dark.

These whales are certainly odontocetes, if only for the single blowhole (Pl. III, Fig. 1). They have no beak, and so are not ziphiids but delphinids. They are not killer whales *Orcinus orca*, for the dorsal fin, although high, is really not like that of either the male or female killer, and nor do they have the bold piebald pigmentation of the killer. The pigmy killer whale, *Feresa attenuata*, is too small and has a different dorsal fin (Nishiwaki, Kasuya, Kamiya, Tobayama and Nakajima, 1965, Fig. 6). Risso's dolphin, *Grampus griseus*, has a similar pigmentation when observed at sea, and the dorsal fin is similar to, although not so high and rather more falcate than, the fin of our whale (Pilleri and Knuckey, 1968, Pls VIII–XI; Mitchell (edit.), 1975, Fig. 24); but Risso's dolphin does not exceed 4 m (13 ft) in length. As may be seen from Pilleri's photographs of the false killer whale, *Pseudorca crassidens*, at sea (1967, Pls. I–IV), the dorsal fin of the false killer comes closest to that of our whale in shape, although the false killer's fin is not so high; the body size of the false killer is also about the same, and although the colour is said to be black, relieved only by white scar marks, there appear to be small white patches on the back of some individuals in Pilleri's photographs, and white markings on the head and flippers of stranded specimens photographed by J. G. Mead (in Mitchell (ed.), 1975, Fig. 14).

We can only conclude that these whales seen off Chile in 1964 may be a new species, possibly of the genus *Pseudorca* or *Grampus*. It is clearly important to obtain specimens as soon as opportunity affords. The animal agrees well with the 'undescribed whale' reported and figured by Wilson (1905, p. 472; 1907, p. 4 and Whales, Plate I) as 20–30 feet long, black above but with some white about the mouth or chin, and characterised by a high dorsal fin 'erect, pointed and sabre-shaped'; several were seen in the Ross Sea during the British National Antarctic Expedition (1901–1904), but they have never been reported since.

Dolphins (Tursiops sp.)

We have already explained (p. 127) the observed difference in abundance of dolphins sighted off Chile in 1964 (1.7 per 100 nautical miles sailed) compared with their abundance over the same track in 1958 (15.6 per 100 nautical miles sailed).

Dolphins were sighted on four occasions during the expedition of 1964 (Table 1). They were all of the same species which we have not been able to identify with certainty. They were in schools of between six and ten animals. At one sighting the school was accompanied by blackfish, and at another, by blackfish and a fin whale (p. 149). The estimated lengths of the dolphins varied from 1.5 m (5 ft) to 2.4 m (8 ft). Two which played at the bow of the ship could be observed fairly closely, and were photographed when just under water (Pl. III,

Fig. 2). All were slender dolphins, similar in build, dorsal fin and flukes to the common dolphin, *Delphinus delphis*, but with a different colouration. The tailstock was strongly compressed. The beak was fairly short. The anterior border of the flipper was convex: the posterior border was concave from the tip to a point near the insertion; at this point, where the flipper had its greatest breadth, the posterior border became convex, curving inwards to the insertion. The colour was lead-brown above, relieved by some white mottling, especially on the head. In some individuals there were white scratch marks and scars. The lead-brown colour extended to the dorsal fin and the flippers and to the dorsal aspects of the beak and the flukes. The ventral surface was white, including the ventral aspects of the beak and the flukes. The flanks were also white as far as the mid-lateral line of the body.

The compressed tailstock suggests a species of *Lagenorhynchus*. But the form of the flipper is a *Tursiops* characteristic, and there are no features in our notes which exclude *Tursiops*, unless it be that the better known species of *Tursiops* are somewhat more robust than these dolphins. The colour is similar to that of *Tursiops catalania* as described by Fraser (1948). *Tursiops* in the Southeast Pacific is definitely known from two skulls and some notes on body colour from photographs of the individuals which provided them: they are from Talara, Peru and from Isla Santa Cruz, Galápagos Islands, and Hershkovitz (1963) identified them as *T. nesarnack catalania*, which in 1966 he included as a synonym of *T. truncatus aduncus*. Grimwood (1969) has since identified this species as common in Peruvian coastal waters, from Máncora to the Chilean border. We are inclined to think that the dolphins observed in 1964 were a species of *Tursiops*, and Aguayo (1975) was of the same opinion, but we would not commit ourselves until specimens are available for study.

In 1958 also many of the dolphins seen were not identified, although R. Clarke (1962) did report sightings of *Lagenorhynchus cruciger* and the common dolphin *Delphinus delphis*, neither of which were seen in 1964. R. Clarke has discussed previous records of *L. cruciger* from Chile. He saw nothing remarkable about the *D. delphis* he observed (*unpublished notes*), but Banks and Brownell (1969) examined two specimens of the common dolphin from the coast of Peru and concluded that the body proportions fitted those of *D. bairdii* from the Gulf of California, adding ' it appears that there is a *bairdii*-like population of dolphins in the eastern South Pacific Ocean '. But whatever differences may exist between the stocks of common dolphins in different oceans, they can hardly warrant more than the subspecific rank afforded them by Hershkovitz (1966) who gives *D. bairdii* as *D. delphis bairdii*.

Aguayo (1975) has recorded other species of dolphins from Chilean seas.

Porpoises (Phocoena sp.)

Porpoises (*Phocoena* sp.) were sighted on five occasions during the expedition off Chile in 1964 (Table 1). The sightings ranged from 50 to 85 nautical miles from the nearest land, which is unusual for *Phocoena* which is regarded as a coastal form. Their abundance was 5.3 per 100 nautical miles sailed. No porpoises

were encountered sailing the same track in 1958 (see p. 127).

All the porpoises were of the same species. The numbers in schools were as few as six to as many as 50–60. One school of 15–20 was feeding on ' sardine ' (*anchoveta ?*) shoals when first sighted ; another school, of 50–60, was accompanied by flocks of petrels. Both these schools were approached for observation. When chased they ran faster than our maximum speed of 13 knots. Whilst running they repeatedly leapt from the water in true porpoise fashion. They were small, stout porpoises, between 0.9 m (3 ft) and 1.5 m (5 ft) long, mostly about 1.2 m (4 ft). The shapes of the head and dorsal fin were typical of the common porpoise, *Phocoena phocoena*. The animals were coloured lead-brown above and white beneath. The white of the ventral surface extended to the flanks where it merged with the dorsal lead-brown in an area of dirty white. The flukes were darkly pigmented.

Norris and McFarland (1958) reviewed the genus *Phocoena* and concluded that there were only four valid species, *spinipinnis*, *sinus*, *phocoena* and *dioptrica*.

Burmeister's porpoise, *Phocoena spinipinnis* and the spectacled porpoise, *Phocoena dioptrica*, are known only from the southern hemisphere. *P. spinipinnis* is common along the coasts of Chile and Peru, and is known from Uruguay and Argentina (Brownell and Praderi, 1976). The ten records of *P. dioptrica* are from Uruguay, Argentina as far as Tierra del Fuego, the Falkland Islands and South Georgia (Brownell, 1975). But Allen (1925) considered that *P. dioptrica* Lahille 1912 was ' with little doubt ' the same as *Phocoena obtusata* described by Philippi (1893) from a single specimen caught in Talcahuano Bay on the coast of Chile. Fraser (1948) thought this only a possibility, and in 1968 argued that Philippi's *obtusata* should not be given priority until further evidence were forthcoming. Praderi (1971) considered *P. obtusata* a doubtful species. When we examined Philippi's text and figure (1893, Plate III, Fig. 1) we were convinced by Allen's argument that the two species are identical, and there appeared to be confirmation from Donoso-Barros (1975) who examined the holotype of *P. obtusata* in the Museo Nacional de Historia Natural, Santiago de Chile and considered it the same as specimens of *P. dioptrica* in the Museo de la Plata, Argentina. However, Brownell (1975) has also examined the holotype of *P. obtusata* and he believes that it is in fact a species of *Cephalorhynchus*. We therefore accept that the identity of *P. obtusata* still remains in doubt. In 1903 True had suggested, from the appearance of Philippi's figure, that *P. obtusata* might be a *Cephalorhynchus*. Hershkovitz (1966) placed *P. obtusata* simultaneously in the synonymy of *Cephalorhynchus eutropia* Gray, 1846 and in the synonymy (but with a question mark) of *P. dioptrica*.

C. eutropia is a rare dolphin of Chilean seas known mostly from skulls and two skeletons. From characters of the skull True (1903) found this to be almost certainly conspecific with *Tursio* (*Phocoena*) *albiventris* Perez, published by Philippi (1896) who had earlier (1893) named this dolphin *Phocoena* (*Hyperoodon ?*) *albiventris* Perez from a description and figure of the external form and colour provided by Dr. Perez Canto. It had been caught near Valparaiso. In 1896 Perez Canto himself published his description as *Phocoena albiventris* Perez Canto. His account

of the head, dorsal fin and flipper of *P. albiventris* conform with those of the genus *Cephalorhynchus*. His dolphin was small (1.36 m, 4 ft 6 in), greenish-black above, extending to the flanks, with throat and belly white and a white patch behind the flipper. The flukes were pigmented. There was ' a dark line on the sides which runs from front to behind. (This line is not seen in the figure)'. Fraser (1948) called it the white-bellied dolphin, *Cephalorhynchus albiventris*. The ' handsome black and white beakless porpoises ' seen by Murphy (1925, p. 255) near Huacho, Peru may have been specimens of *Cephalorhynchus eutropia*, although Murphy thought they were probably *C. albifrons*, a species which Hershkovitz (1966) includes in the synonymy of *C. hectori* from New Zealand waters. Recently Aguayo (1975) has recorded that Dr. Kenneth S. Norris, in an unpublished report of 1968, took two specimens of a dolphin or porpoise which he identified as *C. eutropia*, and saw many more of the same species at sea between 37° and 40°S on the coast of Chile.

Now the porpoises we saw on the expedition of 1964 were neither Burmeister's porpoise nor the spectacled porpoise. The first author has become familiar with the appearance of *P. spinipinnis*, first in the fish market at Chimbote (R. Clarke, 1962, p. 279, footnote) and thereafter in the markets at Chimbote, Ancón, Callao, Pucusana, San Andres and Ilo, whilst he was fishing on the coast of Peru during 1971 and 1972. Another of us (A.A.L.) has also observed a school of eight *P. spinipinnis* at the mouth of the Loa River in Chile in 1965 (Aguayo, 1975). *P. dioptrica* should be easily recognised at sea, being very distinctly marked in black and white and showing sexual dimorphism of the dorsal fin (Fraser, 1968 ; Brownell, 1975). On the other hand our porpoises could have been, with regard to size and colour pattern, the white-bellied dolphin *C. eutropia* as described by Perez Canto ; his ' dark line on the sides ' could have been the dirty white area on the flanks of our porpoises where dark and white merged. But again, our field notes say that the head and dorsal fin were typical of *Phocoena*.

We come now to compare the northern species, *Phocoena phocoena* and *P. sinus*, with our porpoise. In the external characters we were able to observe, it only differs from *P. phocoena* in its rather smaller size and the lead-brown colour of the back which is black in *P. phocoena*. The latter is widely distributed in northern seas, but it has not been reported from the southern hemisphere, which is not to say that our porpoise may not be a southern race of the species. On the other hand, Norris and McFarland (1958) described a new porpoise, *Phocoena sinus*, from a skull cast up in the Gulf of California. Little is known of the colour pattern of *P. sinus* (Brownell, 1976), but there have been sightings of porpoises believed to belong to this species, where the animal is described as rather less than five feet in length, and of a uniform brown colour dorsally (Norris and McFarland, 1958), as five to six feet long and ' dull lead grey in colour with a slight brownish cast ', and as somewhat over four feet long, and lead grey above grading to white below (observers cited by Norris and Prescott, 1961). The size and colour of our porpoise agree with these observations, but *P. sinus* is considered at present to have a very limited distribution in the Gulf of California (Brownell, 1976).

We therefore prefer to record our porpoise as *Phocoena* sp. until such time as

specimens may be obtained.

R. Clarke (1962) called attention to the paucity of our knowledge of the taxonomy and bionomics of the smaller cetaceans of the Southeast Pacific. His remarks are reinforced by this discussion of the small whales, dolphins and porpoises we could not identify in the expedition of 1964.

WHALE MARKING

During the expedition 53 sperm whales and one fin whale were estimated to have been effectively marked. The positions of marking are shown in Fig. 1. A copy of the whale marking records is lodged with the Whale Research Unit, British Antarctic Survey, Cambridge, United Kingdom.

Methods and precautions

The procedures of marking whales (Pl. IV, Fig. 1) and recording the results followed those used in 1958 and 1959 and were similar to those described by R. Clarke and Ruud (1954). Before firing all marks were smeared with an antibiotic ointment to guard against infection of the wound of entry of the mark, as recommended by Ruud, Clarke and Jonsgård (1953) and R. Clarke (1971). To avoid the risk of a mark penetrating to the body cavity of the whale, the marksman aimed at the region of the dorsal fin of whalebone whales (Ruud, Clarke and Jonsgård, 1953), but the aim was directed at the region behind the dorsal fin when marking sperm whales, for reasons explained by R. Clarke (1971). On the voyages of 1958 and 1959 in Chilean and Ecuadorean seas, no whales estimated to be less than 38 ft (11.6 m) in length were marked, because the first author of the present paper considered them too small to be marked without risk of injuring the whale. But few female sperm whales exceed 38 feet, and on the voyage of 1964 we reduced this minimum size for marking to 36 ft (11.0 m) so as to make available the larger female sperm whales and also more of the smaller males. We agree with Clarke (1971) that, unless there is experimental evidence to the contrary from the marking of carcases, a minimum length of 36 feet should be strictly observed for the safe marking of any species of whale where the standard 12-bore *Discovery* mark is employed.

TABLE 9. WHALE MARKS EXPENDED OFF THE COAST OF CHILE IN 1964

Result of shot	Fin	Sei	Sperm	Total	Percent
Hit	1		56*	57*	62
Hit, mark protruding			8	8	9
Possible hit			5	5	5
Ricochet			4	4	4
Miss		4	13	17	18
No verdict				0	0
Wasted				1	1
Total expenditure	1	4	86	92	99

* Three whales marked twice.

Whale marks and their expenditure

The expenditure of whale marks is shown in Table 9. About 25% of the sperm whales sighted were considered to have been effectively marked, and we could have marked many more had we not observed the minimum size for marking of 36 ft.

The blubber of sperm whales is very hard: when marking sperm whales off the coast of Chile in 1958, a large proportion of the marks which scored hits were seen to protrude from the blubber. Whales struck in this way are not considered to be effectively marked, because no mark recorded as protruding has ever been recovered from a whale (with one exception), presumably because the mark eventually falls out from the blubber. Accordingly, for the marking in Ecuadorean seas in 1959, a mark was developed with a slightly more powerful cartridge than that used for whalebone whales. The modified mark proved successful in 1959 (R. Clarke, 1962), and these special marks for sperm whales were also used off Chile in 1964. Of the combined total from 56 hits and eight hits with the mark protruding on sperm whales (Table 9), 13% were hits with the mark protruding which we consider very satisfactory. R. Clarke (1962) gave details of the modification, and we recommend these marks for future use on sperm whales.

Recoveries of whale marks

Up to the time of completing this report, two of the sperm whales marked in 1964 have been recaptured.

Mark no. 23539 was fired into a male sperm whale, estimated to be 49 ft (14.9 m) long, at three miles from Isla Chañaral in 29°01'S, 71°41'W on 30 November 1964, and the whale was in an unclassified school (Table 1, time 0715 to 1020). It was shot on 7 January 1967 in 36°40'S, 73°40'W near Talcahuano where the mark was recovered and the length of the whale recorded as 37 ft. This figure for length must have been a clerical error at the whaling station because we believe that our estimates of the sizes of whales approached for marking were accurate within one foot. The recovery establishes a local displacement of 470 nautical miles southward parallel to the coast in three years (Fig. 4). Although there is no way of knowing the whale's movements in the interval between marking and recovery, this is evidence that sperm whales are indeed moving through the seas adjacent to the coast of central Chile, and that the stock is a local one in the sense that the whales return to the same ground. Perhaps the date of recovery is significant also, because if the whales in successive years were to keep to the same procession of movement with time, then we might well expect a sperm whale which is off Isla Chañaral in November, embarked on a leisurely southward migration combined with feeding, to be off Talcahuano five weeks later in January.

The second recovery is especially interesting, as Brown (1976) has noted. Mark no. 23598 was fired into a male sperm whale, estimated as 40 ft (12.2 m) long, in 29°42'S, 71°37'W where it was one of the great concentration of 90–110 sperm whales (which included harem schools, Table 1) encountered SW of Isla Pájaros on 30 November 1964. The whale was shot in the Bellingshausen Sea

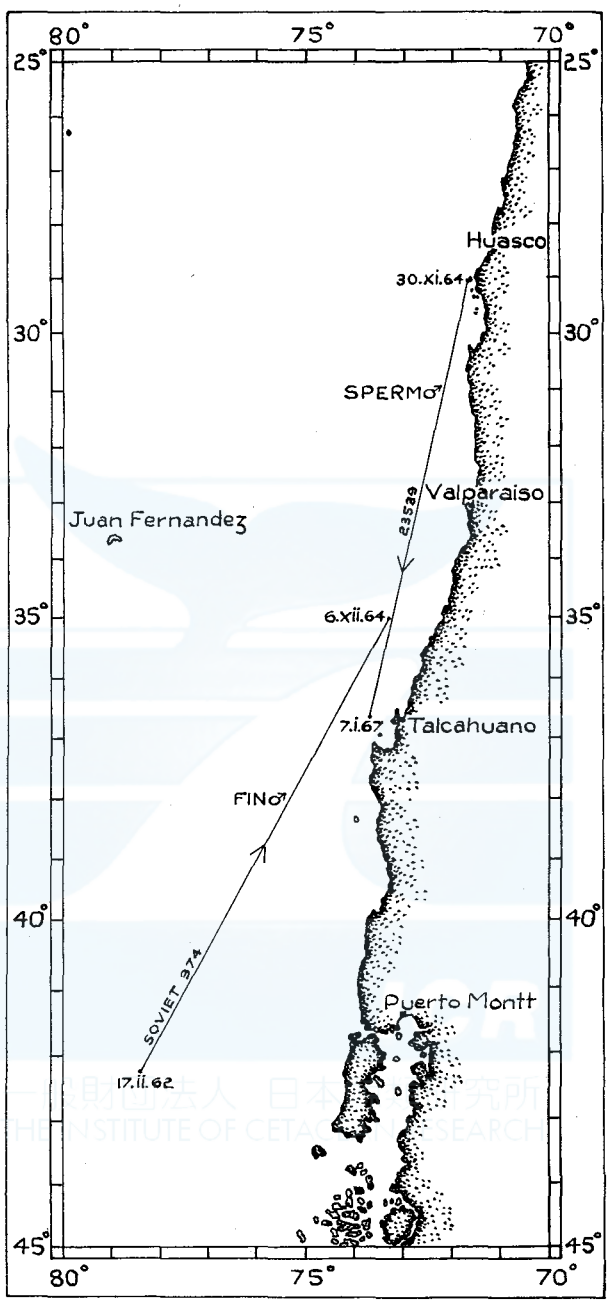

Fig. 4. Recoveries on the coast of Chile of a sperm whale marked in 1964, and of a fin whale bearing a Soviet mark.

in 66°01'S, 83°03'W on 19 December 1973, and it was recorded as 46 ft (14.0 m) long. This recovery after nine years shows a southerly movement of 2,200 nautical miles by the shortest route from sub-tropical latitudes deep into Antarctic Area I (Fig. 5), and is direct evidence from whale marking of the migration into the Antarctic of male sperm whales from the breeding stock of low latitudes. A less extensive penetration into the Antarctic has also been demonstrated from West Australian waters where a sperm whale marked off Albany in 1963 was recovered in 1971 south of Tasmania in 46°31'S, 148°42'E (Brown, 1973). There is one other marking record from elsewhere which shows the return migration: a male sperm whale marked by a Soviet vessel in the Antarctic in the western part of Area III in December 1967 was recovered four and a half months later 2,000

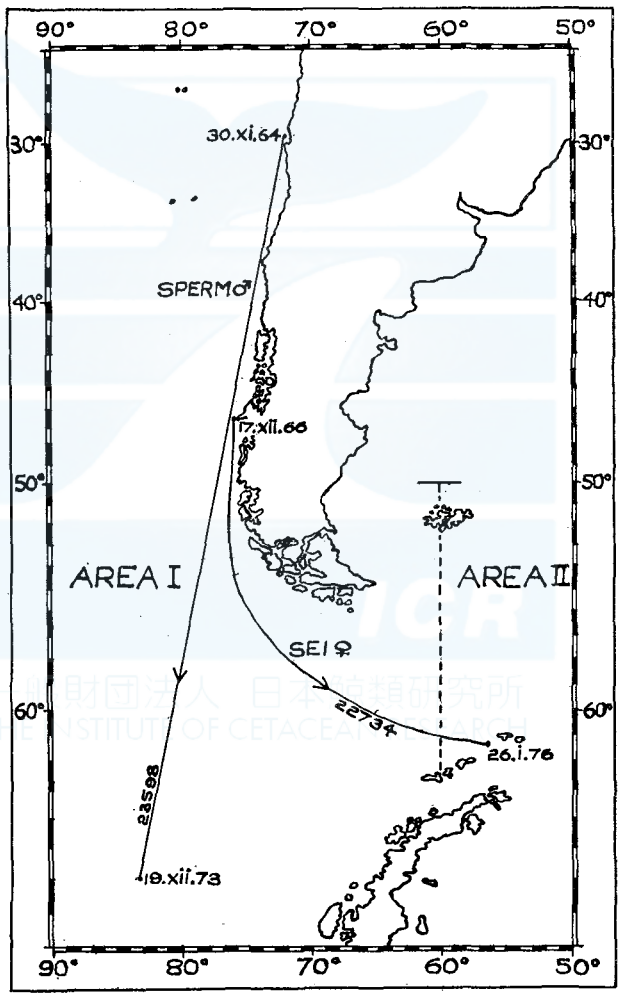

Fig. 5. Recoveries in the Antarctic of a sperm whale marked in 1964 and of a sei whale marked in 1966 off Chile.

nautical miles to the northward in the Indian Ocean off Durban (Best, 1969b).

The recovery of mark no. 23598 is also of interest regarding age determination in sperm whales. Most workers are now agreed that the rate of accumulation of dentinal growth layers in the teeth is one per year (Ohsumi, Kasuya and Nishiwaki, 1963; Best, 1970a; Gambell, 1972) but Berzin (1971) believes that two layers accumulate each year. In Best's mean growth curve for male sperm whales off the west coast of South Africa (1970a, Fig. 5), growth from 40 to 46 ft corresponds with an increase of eight dentinal growth layers, from 21 to 29, so that growth of the whale with mark no. 23598 from 40 ft (estimated) to 46 ft in nine years supports a rate of accumulation of one growth layer each year.

No further marks have been recovered from the voyage of 1964, and there are no additions to the recoveries discussed by R. Clarke (1962) from the voyage off Chile in 1958, whilst so far there have been no recoveries from the voyage of 1959 in Ecuadorean seas. However, we may appropriately discuss here two recoveries from whalebone whales marked on other voyages off the coast of Chile.

We are indebted to Dr M. V. Ivashin of the All-Union Research Institute of Marine Fisheries and Oceanography, Moscow for details of the marking of a fin whale with Soviet mark no. 974 on 17 February 1962 in 42°20'S, 78°23'W. The whale was shot on 6 December 1964 in 35°S, 73°10'W and the mark recovered at Quintay where the whale was recorded as a male 19.8 m (65 ft) long. The minimum displacement was 500 nautical miles after nearly three years (Fig. 4). The recovery is evidence that the same fin whales are moving off the coast of Chile from year to year. Although the recovery gives no information on the actual range of the whale's movements in the interim after marking, it was probably in February 1962 at the rear of the procession of fin whales which was moving past southern Chile into the Antarctic in the summer of 1961/62, because we know, from the recapture in Antarctic Area II of four fin whales from 11 marked off Chile in 1958, that the fin whales off the coast of central Chile in spring are migrants belonging to a stock which moves through Drake Strait to frequent the western part of the Atlantic sector of the Antarctic in summer (R. Clarke, 1962).

The other recovery is from a sei whale marked by one of us (A.A.L.) with two marks, nos 22734 and 22741, off the Taitao Peninsula of southern Chile in 46°32'S, 75°55'W on 17 December 1966, when it was estimated to be 49 ft (14.9 m) long. The marks were recovered (no. 22734 from the whale, no. 22741 from the factory ship deck) in the western part of Antarctic Area II, 61°20'S, 56°22'W, on 26 January 1976, and the whale was recorded as a female, 52 ft (15.9 m) long. The minimum displacement after nine years was about 1,250 nautical miles (Fig. 5). Reporting the recovery, Brown (1977) has emphasised that this movement through Drake Strait into the western Atlantic sector of the Antarctic is directly comparable with that of fin whales marked off Chile in 1958.

The direct evidence from whale marking reviewed here shows that not only fin whales, but also some parts of the sei whale stock and the male sperm whale stock of the Southeast Pacific are exploited on their migrations by coastal whaling from Chile, where regulation is under the Permanent Commission of the South

TABLE 10. FISHING FOR SQUIDS AND FISH BY

Station No.	Date	Position	Duration	Surface Temp. °C	Bait	Casts	
						Depth m	Duration min.
I_{14}	24. xi	33°04′S, 72°28′W	2145–2330	16.1°		50	15
						100	15
I_{15}	25. xi	33°15′S, 75°00′W	2120–2155	16.9°	—	—	—
I_{16}	26. xi	31°20′S, 73°55′W	2110–2255	17.0°		25	5
						50	10
I_{17}	27. xi	30°42′S, 72°00′W	2110–2135	15.6°	Putrid meat	25	2
						50	5
						50	15
I_{18}	28. xi	29°16′S, 71°47′W	2230–2330	15.1°	Putrid meat	50	30
I_{19}	29. xi	28°38′S, 72°00′W	2115–2130	17.0°	—	—	—
I_{20}	1. xii	30°15′S, 72°31′W	2130–2215	17.5°	Fish (Jurel, *Trachurus trachurus*)	25	15
						50	15
I_{21}	2. xii	30°17′S, 75°00′W	2000–2015	18.1°	—	—	—
I_{22}	3. xii	30°27′S, 74°08′W	0345–0600		—	—	—
I_{23}	3–4. xii	31°57′S, 73°10′W	2000/3–0600/4	17.2°		25	15
						50	15
I_{24}	7. xii	34°07′S, 72°17′W	2145–2230	17.2°	None	4	20
I_{25}	8. xii	35°24′S, 73°33′W	2150–2235	17.6°	None	25	15
						50	15
I_{26}	9–10. xii	35°17′S, 75°00′W	2050/9–0200/10	17.3°	—	—	—
I_{27}	10. xii	36°16′S, 74°54′W	2045–2330	16.8°	Meat	50	30
					Garfish	25, 50	30

Continued . . .

INDUS XIV OFF THE COAST OF CHILE IN 1964

Squid fishing

Strikes	Captures	No. of strikes and/or captures per hour	Remarks	Other observations
0	0	0		Schools of garfish (*Scomberesox*) passing every 2–3 minutes. Each school contained 50–200 fish.
0	0	0		
—	—	Present	No fishing, but three specimens of *Dosidicus gigas* were washed on deck during the night. Preserved.	Two specimens of *Scomberesox* washed on deck during the night.
0	0	0, but present	Numbers of squids, of 0.4–0.5 m standard length, present at the surface. A large squid, about 2.5 m long, appeared for a moment.	Hand lining for 15 min. at 50 m caught nothing
0	0			
2	1	9	A large *D. gigas* of about 1.5 m standard length was captured, but it broke at the surface and only the head was recovered.	Two specimens of *Scomberesox* washed on deck.
0	0			
0	0	0		Six specimens of *Scomberesox* caught in handnet.
—	—	?		Ship stopped only for basic station routine.
0	0	0, but present	Two squids caught by the watch during the night, but later they were lost.	
0	0			
—	—	?		Ship stopped only for basic station routine.
—	—	Present	Two specimens of *D. gigas* caught by the watch during the night. Preserved.	The watch caught with a handnet 37 specimens of *Scomberesox* and 18 myctophids.
0	0	0, but present	Three specimens of *D. gigas* caught by the watch during the night. Preserved.	Hand lining for 30 minutes between 25 and 50 m caught nothing.
0	0			
4	5	27	A great number of squid, hunting *Scomberesox*, surrounded the ship at the surface (1–4 m). They were all 1.0–1.5 m long. The five captures were *D. gigas*. Preserved. The colour changes of one squid were noted.	A single specimen only of *Scomberesox* was caught.
0	0	0	No squids seen at the surface.	Some *Scomberesox* were seen.
0	0			
—	—	?	Because of a heavy swell, no fishing was attempted.	Some *Scomberesox* were washed on deck as the ship rolled. Nine were preserved.
0	0	0	No squids seen at the surface.	One specimen of *Scomberesox* washed on deck.
0	0			

Continued . . .

TABLE 10.

Station No.	Data	Position	Duration	Surface Temp. °C	Bait	Casts	
						Depth m	Duration min.
I_{28}	11. xii	36°35′S, 73°10′W	1510–1530	16.5°	—	—	—
I_{29}	12. xii	35°41′S, 74°52′W	2030–2045	17.1°	Garfish	50	15
I_{30}	14. xii	33°55′S, 75°26′W	2110–2130	17.5°	—	—	—
I_{31}	15. xii	33°55′S, 74°00′W	2100–2315	16.5°	Garfish	25	15
						50	30

Pacific, and in summer in the Antarctic by factory ships operating under regulations of the International Whaling Commission. This increases the urgency for that close cooperation between the Commissions recommended by R. Clarke (1962) after discussing fin whale migrations.

OTHER WORK ON THE VOYAGE

Each night in 1964 when the ship was stopped a brief oceanographical station was worked ; the data and samples have been deposited with the Estación de Biología Marina de Montemar. The routine comprised a surface water sample and surface temperature record, and vertical hauls with phytoplankton net and zooplankton net from 20 m to the surface (Fig. 1, Table 10). The stations were numbered I_{14} to I_{31} in continuation of the similar stations (I_1–I_{13}) worked on the voyage of 1958 (R. Clarke, 1962).

Station I_{28} was worked in the daytime to sample the only patch of discoloured water seen on the voyage (Table 10). There were two occasions when the ship continued sailing through the night, so that we stopped only to work the basic routines of stations I_{19} and I_{21}. At all the remaining 15 night stations we fished under a cargo light for squid with hand lines and for fish with a hand net.

Fish

The only fish seen or caught were myctophids and garfish.

The myctophids were recorded at only one station, I_{22}, and the catch appeared similar to *Myctophum clarkei* de Buen, taken during the voyage of 1958 (R. Clarke, 1962).

The garfish were widely distributed on the track of the voyage, being present at ten of the 15 stations where fishing was conducted. They were sampled at seven of the stations and all the samples have been identified by Dr Walter Fischer as *Scomberesox stolatus* de Buen. This is the *punto fijo* of Chilean seas, formerly confused with *Scomberesox equirostrum* Le Sueur and described, from specimens collected on the voyage of 1958, as a new species by de Buen in 1959. Our unsexed sample

Continued.

Squid fishing				
Strikes	Captures	No. of strikes and/or captures per hour	Remarks	Other observations
—	—	?	No fishing.	Ship stopped to sample a patch of discoloured water, 3–10 m in diameter, of reddish brown colour
0	0	0	No squids seen the surface.	
—	—	?	No fishing. No squids were seen at the surface.	Three specimens of *Scomberesox* washed on deck.
0	0	0	No squids seen at the surface.	
0	0	0		

of 45 individuals from 1964 had a mean length of 32.33±6.39 cm. As on the voyage of 1958, *S. stolatus* was abundant and sometimes present in immense numbers. At station I_{14} schools of 50–200 *Scomberesox* were passing every 2–3 minutes for a period of 105 minutes.

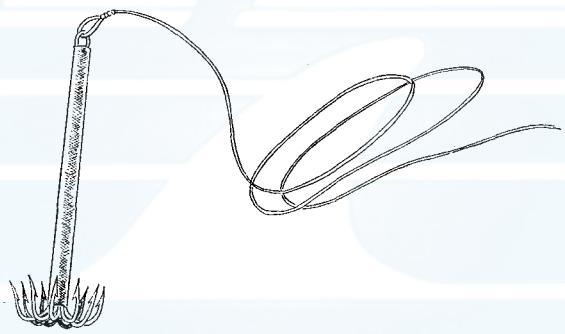

Fig. 6. The *tota* used in fishing for squid from the *INDUS XIV*.

The squid Dosidicus gigas

Table 10 shows the results of fishing for squid. The hand lines were mostly fished at 25 m and 50 m for periods of 15–60 minutes; one cast at 100 m yielded nothing. We used a jig called the *tota* by Chilean squid fishermen (Fig. 6). It is a copper tube, 1.6 cm in diameter and 15 cm long, with about 12 fish hooks protruding in a rosette from one end. The baits used were putrid meat, garfish, and the fish *jurel* (*Trachurus trachurus*), although our best catch, at station I_{24} was made without bait, using the *tota* purely as a jig at 4 m depth. In other seas use of the unbaited jig for squid fishing is widespread (Lane, 1957, p. 132).

Squid were either seen or caught at seven of the 15 night stations. The 14 captures were preserved by injection with 10% formalin (Pl. IV, Fig. 2), and later deposited at Montemar where all were identified as *Docidicus gigas* by Mr Patricio

TABLE 11. RECORDS OF THE HUMBOLDT CURRENT SQUID *DOSIDICUS GIGAS* COLLECTED BY *INDUS XIV* OFF THE COAST OF CHILE IN 1964

Station No.	Sex	1) Total length cm	1) Standard length cm	2) Mantle length cm	2) Width of fins cm	2) Length of fins cm	Sexual maturity	Stomach contents
I_{15}	Male	48	44	26.5	—	—	Imm.	Empty, except for a few fish remains
	Male	47	42	24.5	—	—	Imm.	Full of fish remains
	Male	47	41.3	24	—	—	Imm.	Empty, except for a few fish remains
I_{17}		ca 150		(Only the head recovered. Longest arm 44 cm, tentacles 62 cm)				
I_{22}	Female	130	110	59	45	31	Imm.	Fish remains
	Male	129	110	59	—	—	Mat.	Fish remains
I_{23}	Female	121	103	58	—	—	Imm.	Full of fish remains
	Female	118	100	55	—	—	Imm.	Fish remains
	Female	97	80	47	33	24	Imm.	
I_{24}	Female	141	114	59	—	—	Imm.	Fish remains, and remains of a squid tentacle which was not *D. gigas*
	Female	133	109	58	—	—	Imm.	Empty except for fluid
	Female	121	103	57	—	—	Imm.	Empty
	Male	118	108	55	—	—	Mat.	Remains of squid, possibly *D. gigas*
	Male	116	94	48	37	25	Imm.	Empty

1) Measured fresh

2) Measured after preservation in 10% formol.

García-Tello. We are confident that those we saw at the surface but did not catch were also *D. gigas*, as were those seen or captured on the voyage of 1958 (R. Clarke, 1962). This squid is important in the diet of sperm whales in the Southeast Pacific, and we have already discussed our results on the incidence and abundance of *D. gigas* in relation to the distribution of the sperm whales sighted (p. 144 ff). We give here our observations on the squid itself.

The largest individual seen was about 2.5 m (8 ft 6 in) long and appeared for a moment at the surface at Station I_{16}. The largest hooked was about 1.5 m (5 ft) long but only the head was recovered. Duncan (1941) recorded a capture 9 ft (2.7 m) long, and Professor Gilbert L. Voss, reported by Lane (1957, p. 131), says that *D. gigas* growths to a total length of 12 ft (3.7 m) and mantle length 6 ft (1.8 m). Table 11 records Mr Patricio García-Tello's examination of our captures. On these data males are seen to become sexually mature between 1.16 m and 1.18 m total length, say 1.17 m (mantle length, 0.52 m), whilst females are still immature at 1.41 m (mantle length, 0.59 m). This indicates that the females of *D. gigas* are larger than the males, unless the latter grow more rapidly after sexual maturity.

The fish remains which occurred in eight of the nine stomachs of *D. gigas* which contained food (Table 11) probably included *Scomberesox stolatus*, for we saw the squid feeding voraciously on this fish at Station I_{24}. R. Clarke (1962) also reported them feeding on *S. stolatus* during the voyage of 1958. '*Scomberesox equirostrum*' (*S. stolatus*) was found by de Sylva (1962) in one out of six stomachs containing food in specimens of *D. gigas* caught off northern Chile. The stomach of one of the squids from Station I_{24} contained the remains of squid, possibly *D. gigas* (Table 11). This was to be expected because at Station I_{11} the free-swimming squids were seen to attack their captured fellows as the line was hauled. Duncan (1941) and Wilhelm (1954) have also reported cannibalism in this species.

The captured *D. gigas* showed spectacular colour changes when brought on deck. One specimen at Station I_{24} showed the following changes over the mantle within three minutes of reaching the deck: lead-brown, deep crimson, ochre, dirty cream, brick-red and reddish-brown.

SUMMARY

An account is given of an expedition in the whalecatcher *Indus XIV* to observe and mark whales off the coast of Chile between 28° and 37°S from 24 November to 17 December 1964. This voyage repeated (with a small extension to the southward) the track of an earlier expedition conducted from 21 October to 6 November 1958, and a major object was to compare the abundance of the exploited whale species after a lapse of six years.

In 1964 there were sighted 209–224 great whales, comprising 199–219 sperm whales, four blue whales, one fin whale, one sei whale, and four whales far away, of which three were whalebone whales.

The sighting of four blue whales on the southern part of the track of 1964 prompts a discussion on the presence of the pigmy blue whale, *Balaenoptera musculus brevicauda* as well as the much depleted ' main stock' blue whale *B. m. intermedia* off the coast of Chile.

A drastic reduction in the abundance of fin whales, from 5.1 per 100 nautical miles sailed in 1958 to 0.1 in 1964, is attributed to the effect of Antarctic whaling because whale marks recovered from the voyage of 1958 have established that fin whales off Chile in spring are migrating to the Antarctic. Subsequent intensive fin whaling from Chile in 1964–66 further depleted the stock. Fin whaling in the Antarctic has been prohibited by the International Whaling Commission since 1976, and there is reason for the Permanent Commission of the South Pacific to prohibit the taking of fin whales in Chile and Peru likewise until the stock shall have recovered.

One sei whale was sighted in 1964 as also in 1958. Sei whales and Bryde's whales are both present off Chile, and the possibility of distinguishing them at sea is discussed.

In 1964 there were sighted 11.9 sperm whales per 100 nautical miles sailed compared with 1.7 in 1958. This increase is attributed to a seasonal influx into the area of the breeding stock moving southwards, as shown by the presence in November-December (of 1964) of few solitary males, larger schools, more females and calves and young whales, and a general southerly movement of the whales not feeding, compared with the situation in October-November (of 1958). Thus it is not suggested that the stock had increased between 1958 and 1964, but there was no evidence of a decline.

The distribution of sperm whale schools in relation to surface temperatures in 1958 and 1964 does not support Schubert's conclusion (1951, 1955) that in the Humboldt Current there is an orderly segregation from the coast westward of solitary males in the coldest water, followed successively by bachelor schools and female schools in the warmer water. Solitary males were seen in water of 13.6°–18.7°C, and females in harem schools in water as cold as 14°C, although nursery schools seemed limited to water not colder than 18°C. Limiting temperatures observed for females and calves in other seas are reviewed, and it is concluded that in the southern hemisphere the temperatures at the subtropical convergence are in general those at the limits of female distribution.

Because the large Humboldt Current squid, *Dosidicus gigas*, is known to be important in the diet of sperm whales in the Southeast Pacific, an attempt was made to correlate the distribution and abundance of sperm whales with those of *D. gigas*, as revealed by squid fishing during night stations worked in 1964. No such correlation was observed and possible reasons are suggested. A discussion follows on the fact that in other seas surface-living ommastrephid squid are eaten rarely or not at all by sperm whales.

From the external characters of blackfish observed in 1964, the species is tentatively identified as *Globicephala melaena edwardi* and its general distribution in the Southeast Pacific is reviewed. Distribution and abundance off Chile were

very similar in 1958 and 1964, the abundance being 11.0 per 100 nautical miles sailed in 1964 and 13.2 in 1958. Since blackfish are at present unexploited from Chile no change in abundance was to be expected between 1958 and 1964, and these results on blackfish lend confidence to the comparisons of the abundance of other whales on the two voyages. The schooling of blackfish and their habit of mingling with other cetaceans are reviewed. From the results of the voyages of 1958 and 1964 it is recommended that the blackfish resource off Chile should be exploited by a controlled fishery.

Two unconfirmed sightings in 1964 of the southern bottlenosed whale, *Hyperoodon planifrons*, lead to a critical review of sightings in Chilean seas of whales believed to be *H. planifrons*, which can easily be confused with other ziphioid whales at sea.

The appearance at sea is described of an unidentified toothed whale, 4.5–6.0 m (15–20 ft) long, schools of which were encountered twice in 1964. It is possibly of the genus *Pseudorca* or *Grampus*, and agrees with the unidentified, high-finned whale described by Wilson (1905, 1907) from the Antarctic.

Dolphins sighted on four occasions in 1964 were all of the same species. Their appearance is described and they are believed to be *Tursiops* sp. Reports are discussed of other dolphins from Chilean seas.

Porpoises, *Phocoena* sp., were sighted on five occasions in 1964, uncharacteristically far off the coast for this genus. They were like the common porpoise *Phocoena phocoena* but smaller. A discussion on their identity leads to a review of species of *Phocoena* and *Cephalorhynchus* described from the Southeast Pacific, and their synonymy.

One fin whale and 53 sperm whales were marked in 1964. Precautions were taken to avoid injury to the whales when marking them. No whales estimated to be less than 36 ft (11 m) long were marked.

Two sperm whales marked in 1964 have been recovered to date. One marked in 29°01′S, 71°41′W was recovered in 36°40′S, 73°40′W, 470 nautical miles to the southward after three years, showing that sperm whales are indeed moving through the seas adjacent to the coast of central Chile, and that the stock is a local one in the sense that the whales return to the same ground. The second whale was marked in 29°42′S, 71°37′W and recovered nine years later to the southward in Antarctic Area I in 66°01′S, 83°03′W, a minimum displacement of 2,200 nautical miles. This is direct evidence of the migration into the Antarctic of male sperm whales from the breeding stock of low latitudes. Also the estimated length of the whale at marking and the length at recovery support the view that one dentine growth layer accumulates in the teeth each year.

Two recoveries are discussed from other whale marking voyages off Chile since 1958. A Soviet whale mark fired into a fin whale on 17 February 1962 in 42°20′S, 78°23′W was recovered nearly three years later 500 nautical miles to the NNE, in 35°S, 73°10′W, and is evidence that the same fin whales are moving off the coast of Chile from year to year. A sei whale marked in 46°32′S, 75°55′W on 17 December 1966 was recovered in the western part of Antarctic Area II in

61°20'S, 56°22'W after nine years, a minimum displacement of 1,125 nautical miles, and showing a migration route like that of fin whales recovered in the Antarctic from marking off Chile in 1958.

This direct evidence that not only the same fin whales, but also the same sei whales and male sperm whales, are being exploited in the Southeast Pacific and in the Antarctic increases the urgent need for close cooperation between the Permanent Commission of the South Pacific and the International Whaling Commission.

Eighteen brief oceanographical stations (I_{14}–I_{31}) were worked when the ship was stopped at night in 1964. Fishing for squid and fish was conducted at 15 stations. The fish caught were myctophids and the garfish *Scomberesox stolatus*. All the squid were *Dosidicus gigas*, and in 14 specimens the males were sexually mature at total length 1.17 m (mantle length, 0.52 m), whilst the females were still immature at 1.41 m total length (mantle length, 0.59 m). The squid were feeding on *Scomberesox stolatus* and on each other.

RESUMEN

Se informa sobre una expedición en el barco cazador *Indus XIV* para observar y marcar ballenas frente a la costa de Chile entre 28° y 37°S desde el 24 de Noviembre hasta el 17 de Diciembre de 1964. Este viaje repitió (con una pequeña extensión hacia el sur) la ruta de una expedición anterior conducida desde el 21 de Octubre hasta el 6 de Noviembre de 1958; y un objetivo mayor fué comparar la abundancia de las especies de ballenas explotadas después de un lapso de seis años.

En 1964 se avistaron 209–224 ballenas grandes, comprendiendo 199–219 cachalotes, cuatro ballenas azules, una ballena de aleta, una ballena boba, y cuatro ballena lejanas, de las cuales tres fueron ballenas con barbas.

El avistamiento de cuatro ballenas azules en la parte sur de la ruta de 1964 promueve una discusión sobre la presencia de la ballena azul pigmea, *Balaenoptera musculus brevicauda* como también de la muy disminuida ballena azul ' existencia principal ' *Balaenoptera musculus intermedia* frente a la costa de Chile.

Una reducción drástica en la abundancia de ballenas de aleta, de 5.1 por 100 millas navegadas en 1958 a 0.1 en 1964, se atribuye al efecto de la caza Antártica porque marcas de ballenas recuperadas desde el viaje de 1958 han establecido que las ballenas de aleta que se encuentran frente a Chile en la primavera están migrando a la Antártica. Posteriormente una caza intensiva de ballenas de aleta desde Chile en 1964–66 disminuyó aún más la existencia. La caza de ballenas de aleta en la Antártica ha sido prohibida por la Comisión Ballenera Internacional desde 1976, y hay igual razón para que la Comisión Permanente del Pacífico Sur prohiba la captura de ballenas de aleta en Chile y Perú hasta que la existencia se haya recuperado.

Una ballena boba fué avistada en 1964 como también en 1958. Ballenas bobas y ballenas de Bryde existen ambas frente a Chile, y se discute la posibilidad de diferenciarlas en el mar.

En 1964 se avistaron 11.9 cachalotes por 100 millas navegadas comparado con 1.7 en 1958. Este aumento es atribuido a un influjo estacional en el área de la existencia de reproducción moviéndose hacia el sur, como se muestra por la presencia en Noviembre-Diciembre (de 1964) de pocos machos solitarios, de grupos más grandes, de más hembras y crías y de juveniles, y un movimiento general hacia el sur de las ballenas que no estaban alimentándose, comparado con la situación en Octubre-Noviembre (de 1958). Por lo tanto no se sugiere que la existencia de cachalotes había aumentado entre 1958 y 1964, pero tampoco hubo evidencia de una disminución.

La distribución de grupos de cachalotes en relación a las temperaturas superficiales en 1958 y 1964 no apoya la conclusión de Schubert (1951, 1955) que en la Corriente de Humboldt hay una segregación ordenada desde la costa hacia el oeste de machos solitarios en las aguas más frías, seguidos sucesivamente por grupos de machos solteros y grupos de hembras en aguas más templadas. Machos solitarios fueron vistos en aguas de 13.6°–18.7°C, y hembras en grupos harenes en aguas tan frías como 14°C, aunque grupos criaderos (grupos de crianza) aquellas parecían limitados a aguas no mas frías que 18°C. Las temperaturas limitantes observadas para las hembras y crías en otros mares son revisadas, y se concluye que en el hemisferio del sur las temperaturas en la convergencia subtropical son en general encontradas en los límites de distribución de las hembras.

Como se sabe que la jibia grande de la Corriente de Humboldt *Dosidicus gigas*, es importante en la dieta de cachalotes en el Pacífico Sur Oriental, se hizo un intento de correlacionar la distribución y abundancia de cachalotes con aquellas de *Dosidicus gigas*, como estuvieron reveladas por la pesca de jibias durante las estaciones nocturnas trabajadas en 1964. No se encontró tal correlación y posibles razones son sugeridas. Sigue una discusión sobre el hecho que en otros mares las jibias epipelágicas de la familia Ommastrephidae son raramente o nunca comidas por cachalotes.

A partir de los caracteres externos de los calderones observados en 1964, la especie es identificada tentativamente como *Globicephala melaena edwardi* y su distribución general en el Pacífico Sur Oriental es revisada. La distribución y abundancia frente a Chile fueron muy semejantes en 1958 y 1964, siendo la abundancia 11.0 por 100 millas navegadas en 1964 y 13.2 en 1958. Como en la actualidad los calderones no son explotados en Chile, no se esperaba cambios en la abundancia entre 1958 y 1964, y estos resultados sobre el calderón dan confianza a las comparaciones de la abundancia de otras ballenas en los dos viajes. El agrupamiento de los calderones, y su costumbre de mezclarse con otros cetáceos, son revisados. De los resultados de los viajes de 1958 y 1964 se recomienda que la existencia de calderones frente a Chile debe ser explotada por una caza controlada.

Dos avistamientos no confirmados en 1964 de la ballena naríz de botella (graur colderón) *Hyperoodon planifrons*, conducen a una revisión crítica de avistamientos en aguas chilenas de ballenas supuestas ser *Hyperoodon planifrons*, las cuales pueden facilmente ser confundidas en el mar con otras ballenas de la familia Ziphiidae.

Se describe la apariencia en el mar de una ballena con dientes no identificada, 4.5–6.0 m (15–20 pies) de largo, grupos de las cuales fueron encontrados dos veces en 1964. Es posiblemente del género *Pseudorca* o *Grampus*, y está de acuerdo con la ballena de aleta alta no identificada descrita por Wilson (1905, 1907) de la Antártica.

Los delfines avistados en cuatro oportunidades en 1964 fueron todos de la misma especie. Se describe su apariencia y se cree que sean *Tursiops* sp. Informes de otros delfines de los mares chilenos son discutidos.

Marsopas, *Phocoena* sp., fueron avistadas en cinco oportunidades en 1964, extrañamente muy lejos de la costa para este género. Ellas eran parecidas a la marsopa común *Phocoena phocoena* pero más pequeñas. Una discusión sobre su identidad conduce a una revista de las especies de *Phocoena* y *Cephalorhynchus* descritas del Pacífico Sur Oriental, y de sus sinonimias.

Una ballena de aleta y 53 cachalotes fueron marcados en 1964. Se tomaron precauciones para evitar dañar a las ballenas cuando se marcaron. No se marcó ninguna ballena estimada ser menor de 11 m (36 pies) de longitud.

Dos cachalotes marcados en 1964 han sido recuperados hasta la fecha. Uno marcado en 29°01′S, 71°41′W fue recuperado en 36°40′S, 73°40′W, 470 millas naúticas hacia el sur después de tres años, mostrando que los cachalotes están en realidad moviéndose través de los mares adyacentes a la costa de Chile central, y que la existencia es una población local en el sentido que las ballenas regresan a la misma zona. La segunda ballena fué marcada en 29°42′S, 71°37′W y recuperada nueve añosm ás tarde hacia el sur en Area I de la Antártica en 66°01′S, 83°03′W, un desplazamiento mínimo de 2,200 millas náuticas. Esto es evidencia directa de la migración hacia la Antártica de cachalotes machos provenientes de la existencia de reproducción de bajas latitudes. También la longitud estimada de la ballena en la marcación y la longitud al recuperarla soportan el punto de vista que una capa de crecimiento de dentina se acumula en los dientes cada año.

Se discuten dos recuperaciones de otros viajes de marcación frente a Chile desde 1958. Una marca soviética disparada a una ballena de aleta el 17 de Febrero de 1962 en 42°20′S, 78°23′W fué recuperada casi tres años más tarde 500 millas naúticas al NNE, en 35°S, 73°10′W, y es evidencia que las mismas ballenas de aleta se están moviendo frente a la costa de Chile de año a año. Una ballena boba marcada en 46°32′S, 75°55′W el 17 de Diciembre de 1966 fué recuperada en la parte oeste de Area II de la Antártica en 61°20′S, 56°22′W después de nueve años, un desplazamiento mínimo de 1,125 millas, y mostrando una ruta de migración como la de las ballenas de aleta recuperadas en la Antártica de la marcación frente a Chile en 1958.

Esta evidencia directa, que no solo las mismas ballenas de aleta sino también las mismas ballenas bobas y cachalotes machos están siendo explotados en el Pacífico Sur Oriental y en la Antártica, aumenta la urgente necesidad de una cooperación estrecha entre la Comisión Permanente del Pacífico Sur y la Comisión Ballenera Internacional.

Dieciocho breves estaciones oceanográficas (I_{14}–I_{31}) fueron trabajadas cuando

el barco estaba parado en las noches en 1964. Pesca de jibias y peces fué conducida en 15 estaciones. Los peces capturados fueron de la familia Myctophidae y el pez aguja (' punto fijo '), *Scomberesox stolatus*. Todas las jibias fueron *Dosidicus gigas*, y en 14 especímenes los machos estuvieron sexualmente maduros a la longitud total de 1.17 m (longitud del manto, 0.52 m) mientras que las hembras fueron aún inmaduras a 1.41 m de longitud total (longitud del manto, 0.59 m). Las jibias estuvieron alimentándose de *Scomberesox stolatus* y de ellas mismas.

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The voyage was made possible by the Ministry of Agriculture of Chile which hired the whalecatcher *Indus XIV* for a period which should not last more than 30 days. This arrangement owed much to the interest and support of the late Mr Fernando Mujica, then Director of the Department of Fisheries and Game, and of the Deputy Director at that time, Mr Carlos Esquivel. The ship was hired from the Compañía Industrial, which collaborated as fully as in 1958. We recall with pleasure the enthusiastic cooperation of Captain José Parra, master of *Indus XIV*, and of his officers and crew, during the voyage.

Whale marks and marking guns were supplied by the National Institute of Oceanography, United Kingdom, as part of the international scheme for cooperation in whale marking. The Permanent Commission for the Exploitation and Conservation of the Marine Resources of the South Pacific, at its Sixth Meeting in Quito in November 1959, confirmed the participation of Chile, Ecuador and Peru in this scheme which is coordinated by the National Institute of Oceanography.

Mr Patricio García-Tello, in 1964 a colleague at the Estación de Biología Marina de Montemar, kindly identified the squid specimens collected and provided most of the information in Table 11. Other colleagues at Montemar who assisted were Dr Walter Fischer, who identified the collections of garfish, and Mrs Nora Aguirre who drew the *tota* shown in Fig. 6.

The first author, who undertook the voyage during his return to Chile in 1964 and 1965 on foreign service from the National Institute of Oceanography of the United Kingdom (see R. Clarke, Aguayo and Paliza, 1968, Part I), extends his best thanks to Dr Walter Fischer and Mr Hector Etcheverry, successively Directors at Montemar whilst he worked at the Station as a guest of the University of Chile ; and his co-authors thank their respective Directors at that time.

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EXPLANATION OF PLATES

PLATE I

Fig. 1. Solitary male sperm whale on 28 November 1964 in 29°16 S, 71°47′W. (Photo: Robert Clarke).

Fig. 2. Harem school of sperm whales on 29 November 1964 in 29°03′S, 71°48′W. (Photo: Robert Clarke).

PLATE II

Fig. 1. Sperm whales, mother and calf from a nursery school, approaching the vessel on 30 November 1964 in 29°35′S, 71°38′W. (Photo: Robert Clarke).

Fig. 2. Blackfish, *Globicephala melaena edwardi*, one of a school of 35–40, on 26 November 1964 in 38°05′S, 74°52′W. The white area behind the dorsal fin may be seen. (Photo: Robert Clarke).

PLATE III

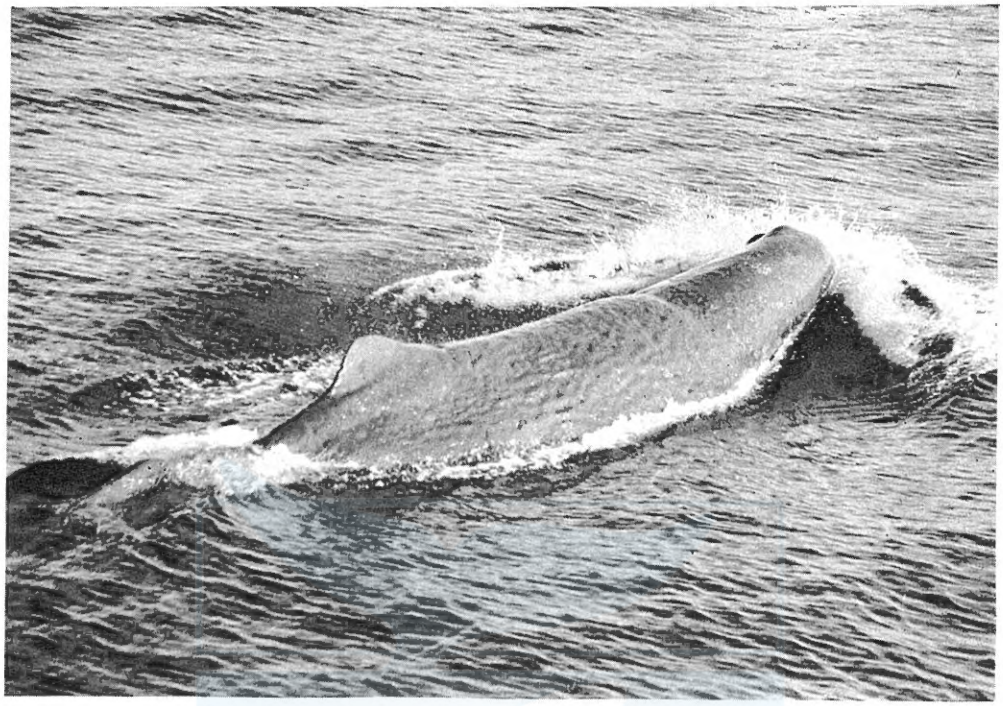
Fig. 1. Unidentified high-finned toothed whales on 24 November 1964 in 33°02′S, 72°11′W. See page 150. (Photo: Robert Clarke).

Fig. 2. Dolphins, believed to be *Tursiops* sp., below water at the bow of the vessel, from a school of eight animals on 27 November 1964 in 31°18′S, 73°41′W. (Photo: Robert Clarke).

PLATE IV

Fig. 1. Marking sperm whales from the whalecatcher *Indus XIV* on 30 November 1964. (Photo: Robert Clarke).

Fig. 2. Measuring and injecting captures of the squid *Dosidicus gigas* on board *Indus XIV* on 8 December 1964. (Photo: Anelio Aguayo L.)



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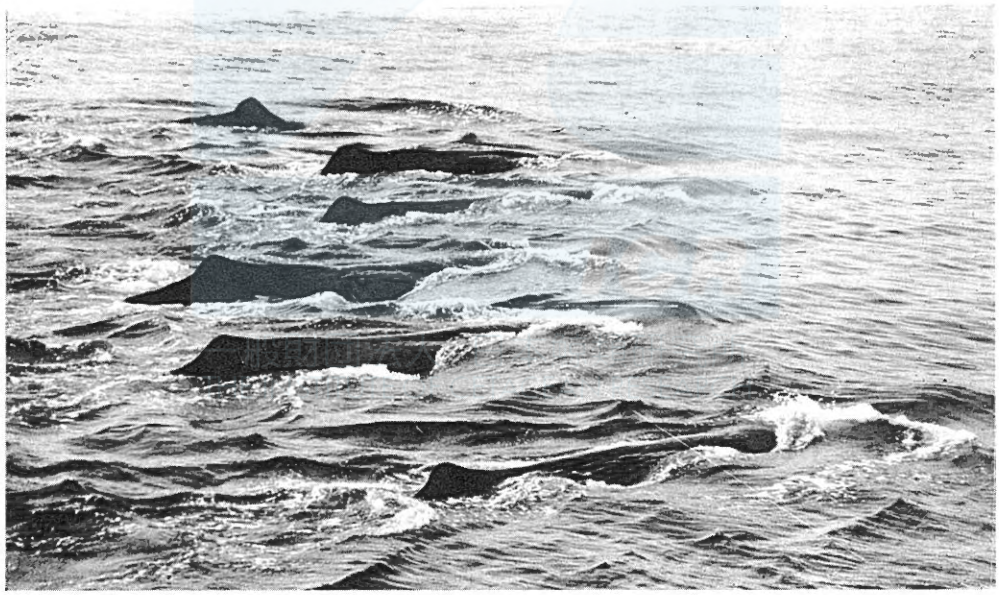

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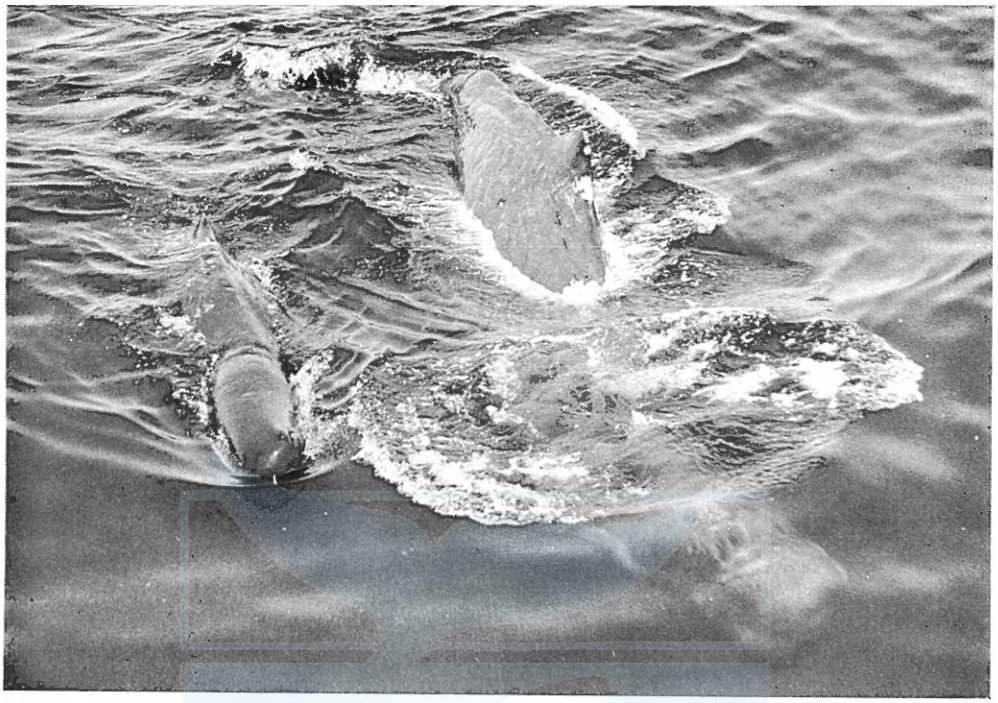

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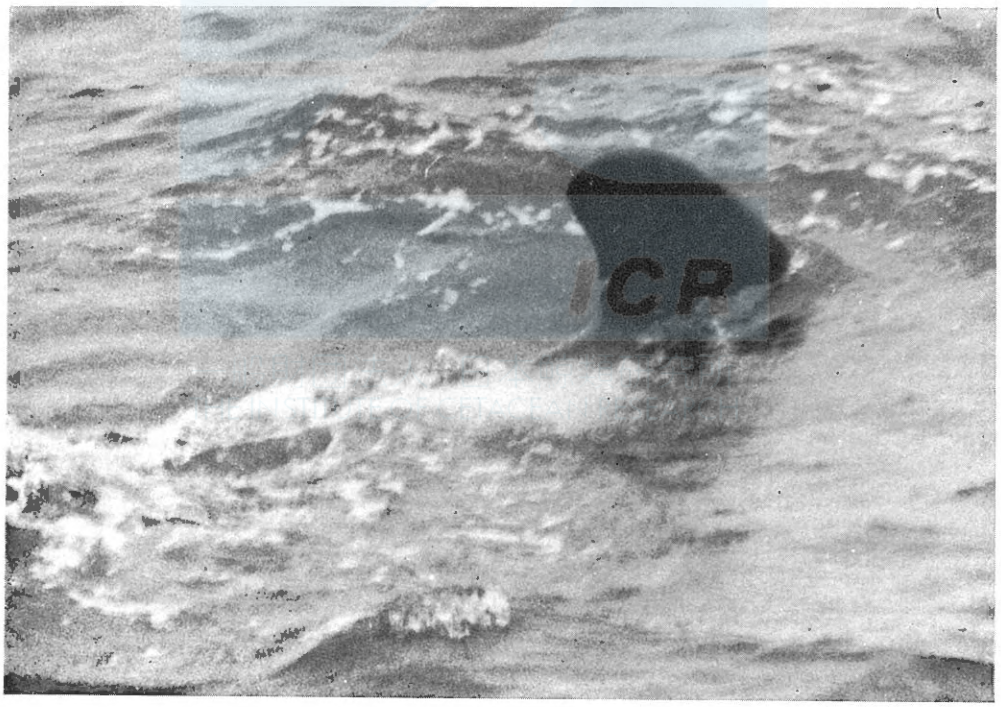

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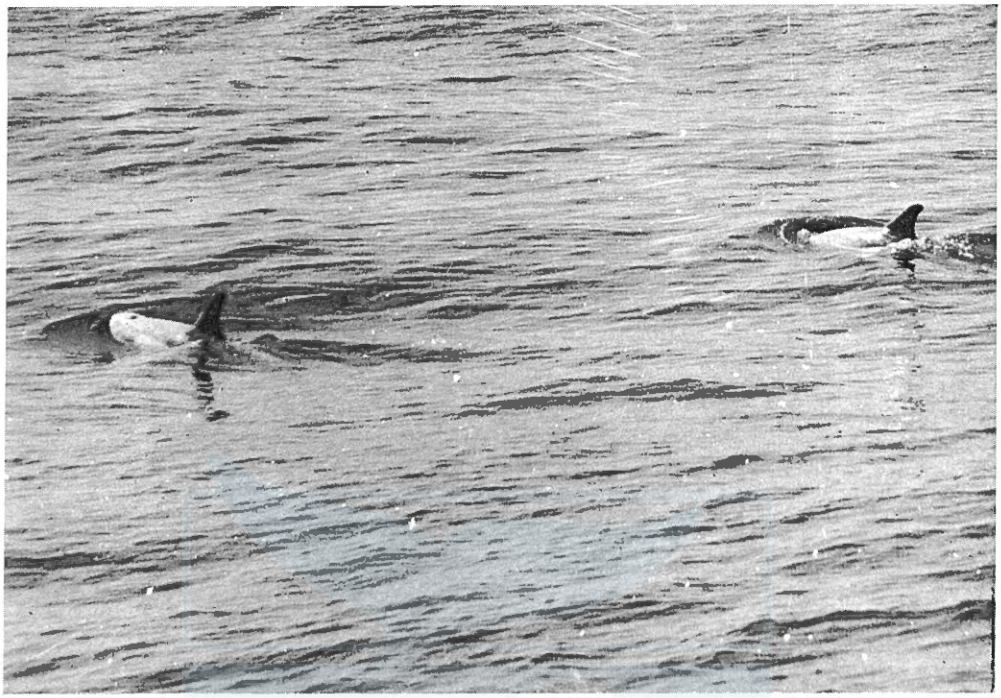

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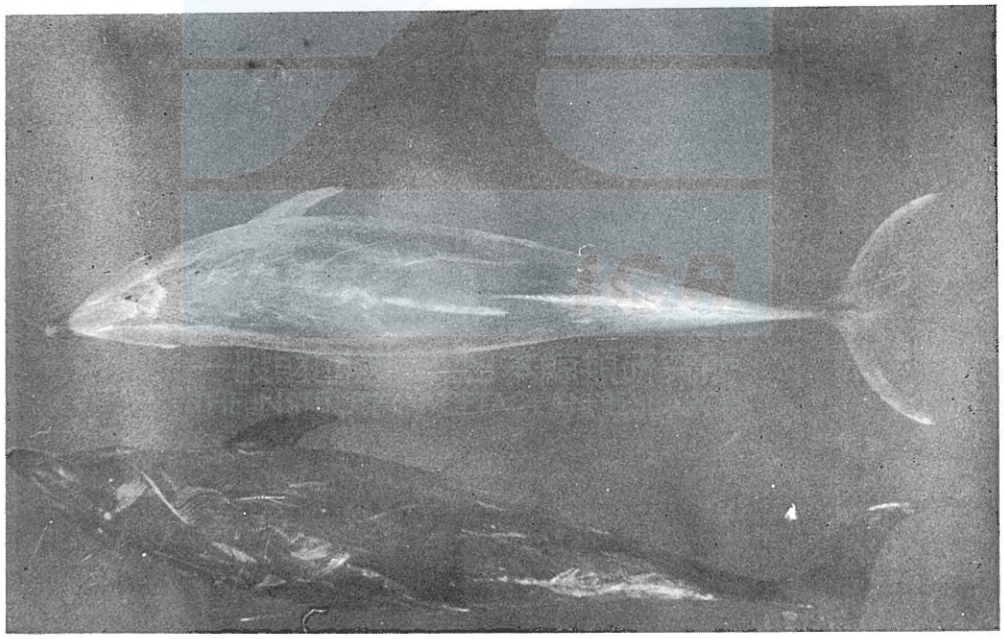

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