BRYDE'S WHALES (BALAENOPTERA EDENI ANDERSON, 1878) OFF EASTERN VENEZUELA (CETACEA, BALAENOPTERIDAE)

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ABSTRACT

Systematic surveys, conducted between 28 October 1978 and 13 November 1979 in the waters adjacent to Puerto la Cruz and Isla Margarita, Venezuela, documented the presence, distribution, and habits of a population of Bryde's whales. Methods included aerial and boat surveys, interviews with local fishermen, and radio-tagging. Bryde's whales, apparently attracted by the abundance of food, were observed in the area between March and December; numbers were greatest in fall. Distribution within the study area varied with season: between March and August the whales were seen in the eastern part; from August to December in the western. Herd size increased from March through October. Although several cow and calf pairs were seen, breeding activities were not, and there is no evidence that this is a breeding area.

INTRODUCTION

This paper reports the result of an investigation of the ecology and behavior of a "population" of Bryde's whales (Balaenoptera edeni) inhabiting the southeastern Caribbean Sea (fig. 1).

Bryde's whales apparently reside year-round in warm-temperate and tropical waters of the world (table 1, fig. 2). Localities where this species has been reported in the southeastern Caribbean Sea are shown in fig. 2. Bryde's whales were captured near Grenada, West Indies, in 1925 and 1926 (Anonymous, 1925; Harmer, 1928); and Soot-Ryen (1961) describes the skeleton of a specimen stranded on Curacao. Additional rorqual sightings in the eastern Caribbean may also have been of B. edeni (Erdman, 1970; Erdman et al., 1973; Caldwell, 1973). Slipjer and van Utrecht (1959) report 8 to 10 rorquals apparently feeding on sardines in Bahia de Pampatar, Isla Margarita. Numerous unidentified whales are reported from near Isla Margarita by Fukuoka (1967) and Gines (1972). The species was first ascertained to be Balaenoptera edeni by Mitchell and Kozicki (1974), from sightings and photographs taken north and east of Isla Margarita.

The impetus for the present investigation was provided by collisions in 1977 and 1978 off eastern Venezuela between passenger-carrying jetfoils and large marine vertebrates of undetermined species. Reconnaissance of the area in October - November 1977 and January 1978 verified that large animals, including manta rays, dolphins and Bryde's whales, did occur in the area, and established the need for detailed research to determine whether high-speed passenger vessels could operate there safely (Anonymous, 1977; Evans et al., 1979).

Between 28 October 1978 and 13 November 1979 five methods (aerial surveys, surface vessel surveys, jetfoil surveys, interviews with fishermen, and radio-tagging and tracking) were used to examine distribution, seasonal abundance, behavior and other aspects of the biology of Bryde's whales in the waters adjacent to Puerto la Cruz and Isla Margarita, Venezuela.

METHODS

Study Area

The principal study area consisted of the waters between 10°05'N and 11°00N, 63°45'W and 64°50'W. It included the jetfoil routes between Puerto la Cruz and Isla Margarita. A peripheral area, bounded by the mainland coast on the south, a line from the mainland coast adjacent to Islas Piritu to Isla Tortuga to Isla La Blanquilla on the west, a line from La Blanquilla to Islas Los Testigos to Bequia, West Indies, on the north, and by a line from Bequia to Punta Penas on the east (fig. 1) was surveyed to a lesser extent.

Two distinct marine topographic regions lie within the area studied. East of approximately 64°20'W the shallow continental shelf reaches its widest dimensions off Venezuela (about 110 km). It is called the Testigos Platform and includes Los Testigos, Margarita, Coche and Cubagua. West of 64°20'W the shelf persists as a narrow west-reaching arm, the Tortuga Bank, which includes Isla Tortuga and forms the northern boundary of the Cariaco Trench. The trench reaches depths of 1,300 m and has steep slopes, sometimes exceeding 11°. Consequently, the principal study area consists of three regions, each with different habitats (fig. 1). Region 1, west of approximately 64°20'W, is characterized by deep blue waters and a steep sloping bottom. Region 2 (east of 64°20'W) has shallow green waters, almost no slope, and frequent strong currents. Region 3, the large Gulf of Cariaco, 65 km long, 16 km wide, is moderately deep and separated from the open sea by a narrow entrance (5.3 km wide).

The entire area is under the influence of the northeastern trade winds. There are only two seasons: a dry season characterized by steady winds, usually beginning in November - December, and a rainy season characterized by irregular winds and frequent squalls, beginning in May - June (MARNR, 1979). Seasonal wind and precipitation conditions are paralleled by seasonality in oceanographic conditions. The North Equatorial Current, joined by a branch of the South Equatorial Current that crosses the equator, enters the Caribbean Sea through the Lesser Antilles. Flowing westward along the Venezuelan coast, this mixed current conveys large amounts of low-salinity water from the mouths of the Orinoco and Amazon rivers during the rainy season (Gade, 1961). Furthermore, in the near-shore areas north and west of Isla Margarita, upwellings from depths below 75 m are reported (Ljoen and Herrera, 1965). These are probably caused by the trade winds' Ekman transport and are also seasonal, being greatest in spring, least in fall (Ljoen and Herrera, 1965; Gines, 1972). Interactions among the physical factors described above create the conditions for rich primary production, which also varies regionally and seasonally, from a yearly average of 283 mg C/m^2/day north of Isla Margarita to 1,860 mg C/m2/day in the Gulf of Cariaco, with spring peaks (Gines, 1972).

Procedures

Aerial Surveys. The principal study area was divided into seven rectangular zones oriented north - south (I - VI) and east - West (VII) (fig. 1). Although of variable length, each zone was 18.5 km (10 nm) wide. For transect selection, north and south boundaries of zones I - VI and east and west boundaries of zone VII were marked off at 0.93 km (0.5 nm) intervals. For each flight two numbers were selected at random for each zone, to serve as transect starting and ending points. These points were connected to assign aircraft headings. A transect set consisted of seven complete transects, one in each zone, and necessary connecting legs between adjacent zones. Sets alternately began from zone I or zone VII, with consequent alternation of transect direction. Total water surface in the principal study area was 5,795 km^2. The survey flights averaged 322.5 linear km over water.

The peripheral region was divided into four additional zones (mainland to Tortuga; Tortuga to Blanquilla; Blanquilla to Testigos; Testigos to mainland) (fig. 1) in which transect selection and direction were as in the principal study area. In the peripheral area water surface was 9,504 km^2. A complete set of four transects averaged 470 km over water.

Efforts were made to schedule the surveys uniformly throughout the year, but few flights could be made in September and October 1979. This was particularly unfortunate as whales were then very abundant.

Between 31 October 1978 and 2 February 1979 observations were made from a low-wing Piper Cherokee. Subsequent surveys were conducted from high-wing Cessnas (models 172, 182, and 206). In addition to the pilot there were 1 (7 flights), 2 (30 flights) or 3 or more (14 flights) observers on board; the principal observer flew in the right front seat, the secondary observer(s) in the rear. I participated in all flights.

Surveys were flow at an average altitude 229 m (750 ft) and an average ground speed of 165 km/h (90 kts). They were not conducted when sea state was estimated at Beaufort 4 or greater (see Leatherwood et al., 1978); such conditions occurred only twice, causing suspension of surveys with only a partial set of data. Nearly all flights were made in the morning, when the sea is usually calm. Landmarks, magnetic bearings, dead reckoning and local navigation aids (ADF) were used for navigation.

On sighting a whale, the plane deviated from the transect and circled at lower speed and altitude to: 1) identify the species, 2) determine herd size, 3) ascertain the presence of young, and record 4) behavior, and 5) faunal associations.

Fifty one flights (188 hours and 14 min of flight time) were made between 31 October 1978 and 9 November 1979. The principal area was surveyed 38 times (12,251 km). The peripheral region was covered completely on six occasions; one survey covered only zones C and D (3,290 km). In addition, six reconnaissance flights were conducted.

Surface Vessel Surveys. Observations and photographs were made at close range from sailing vessels. An 18.5 m schooner was used from December 1978 to January 1979, an 11 m sloop from February to April 1979, and a 12.5 m sloop from May to November 1979. Cruises were concentrated in the principal study area, but occasionally extended to the peripheral region. Two trips were made to Los Testigos (January 1979 and August 1979), two to Grenada and the Grenadine Islands (December 1978 - January 1979, and August 1979), and one to Isla Tortuga (September - October 1979). Survey time totalled 602 daylight hours and covered 4,810 km. Between 12 May and 8 August 1979 boat surveys were reduced (less than 20 hours) because of vessel clearance problems with local authorities.

Jetfoil Surveys. Two jetfoils (manufactured by Boeing Marine Systems, Seattle) operated between Puerto la Cruz and Isla Margarita from 2 February to 15 September 1978 and from 2 March to 28 July 1979. The jetfoil route differed slightly in the two years. In 1978 the port of arrival on Isla Margarita was Porlamar. In 1979 it was moved to Punta de Piedras, shortening the trip by about 15% and avoiding the narrows between Islas Margarita and Coche where whales often congregated (fig. 1).

Observers trained by Hubbs-Sea World Research Institute made regular observations of marine life along the cruise route from the jetfoils. On each trip, two observers, one on each side of the wheelhouse, recorded all whales sighted. Because of irregularity of effort and varying capabilities and motivation of the observers, these data could not be utilized for precise quantitative estimates of distribution and herd size. However, if the observations of the two years are combined to compensate for irregular effort, the data are sufficient to calculate a gross index of whale abundance for various times of the year.

Interviews. To capitalize on the experience of local people, a standardized interview form was administered to fishermen in eleven localities. Questions emphasized species identification, movements, distribution, abundance, seasonality, herd size, presence of young, and behavior.

Radio-tagging and tracking. Between 23 October and 13 November 1979 radio-tagging and tracking experiments were conducted with W. A. Watkins and K. E. Moore of Woods Hole Oceanographic Institution and R. F. Maiefski, San Diego. Two whales were tagged and tracked for a few hours. Details were reported by Watkins et al. (1979).

RESULTS AND DISCUSSION

Taxonomy. In 14 months of study, including the two preliminary surveys, *Balaenoptera edeni* was the only mysticete species identified.

A similar balaenopterid, the sei whale (*Balaenoptera borealis*) has been reported from the Caribbean Sea (Slijper et al., 1964; Erdman, 1970; Erdman et al., 1973; van Bree, 1975) but is very uncommon. In a paper on the distribution of sei whales in the northwestern Atlantic, Mitchell and Kozicki (1974) maintain that sighting reports from Venezuelan waters included both sei and Bryde's whales.

In this study, whales were identified as *B. edeni* chiefly on the basis of the three prominent rostral ridges (fig. 3); on rarer occasions the ventral grooves extending beyond the umbilicus and the coloration of the baleen plates confirmed species identification.

Species identification was supported also by skeletal material available locally: two mounted skeletons on Isla Margarita (one at the Fondacion de la Salle in Punta de Piedras, the other at the Universidad de Oriente in Boca del Rio) and the skull of an individual stranded about 2 km northwest of Isla Tortuga, presumably in late 1978. As Lonnberg (1931), Junge (1950), and Soot-Ryen (1961) point out, Bryde's whales differ from sei whales in having a broader rostrum with a flat, rather than downward arched, dorsal surface; the front margins of the nasalia are bent forwards laterally instead of near the sagittal plane; the spinous processes of the dorsal and part of the lumbar vertebrae are conspicuously inclined backwards, rather than almost vertically; and the vertebral count is 52 - 53 in *B. edeni*, against 56 - 57 in *B. borealis*. Measurements and description of the skeleton at the Fondacion de la Salle were presented by Cagnolaro and Notarbartolo di Sciara (1979). All the diagnostic characters mentioned above confirm the identification as *B. edeni*. The morphology of the nasalia of the skeleton in Boca del Rio and the skull on Isla Tortuga also conformed to that described for Bryde's whales.

Bryde's whales have been designated by various authors as *Balaenoptera edeni* and *B. brydei*, an acknowledgment of the existence of different forms across the species' range. Information is yet insufficient to determine whether or not the two taxa are separate species (Best, 1977). For the present I have referred to the Venezuelan specimens as *B. edeni*, which has priority.

Best (1977) identifies two distinct, allopatric forms of the species: an inshore form - smaller, without scarrings, feeding mostly on epipelagic fish, and without a restricted breeding season; and an offshore form - larger, with abundant scarrings, feeding on euphausiids and mesopelagic fish, and with a more defined breeding season. The ecology of the Venezuelan population seems to fit Best's inshore form, but morphological and life history data to support this hypothesis are lacking.

Morphological notes and coloration. The total length of the skeleton mounted at the Fondacion de la Salle is 1,250 long; when it was alive, the whale must have been over 13 m long, since the atlas and three or four caudal vertebrate are missing. A whale killed by a large ship's propellers near Punta de Piedras in March 1979 was estimated to have been about 12 m long.

Dorsal fins often had a distinctive appearance. They ranged from an almost triangular shape, with a broad base, to a tall and falcate profile (fig. 3). Many were scarred and individually distinctive.

In general appearance, the whales' skin was unblemished and free of scars. Coloration was variable, from light to dark-gray, to almost black. The basic pattern was countershaded, often with a distinct "cape", contrasting with the light color of the thoracic and flank fields. Other features included a light-colored blaze running sagittally along the dorsal field, and a light-gray middle section of the dorsal field, contrasting with the darker anterior and posterior parts of the body. The few times that I could see the whales' central side, the gular and ventral fields and tail flukes were white. The white gular field was clearly delineated rostrally by a dark lower lip. No dark-colored belt separating the white of the gular and ventral fields, as described by Olsen (1913), was observed.

Bryde's whales' baleen plates vary in color (Olsen, 1913). They may be black to dark gray, with two types of bristles: dark-grayish (Olsen, 1913; Omura, 1962a; Leatherwood et al., 1976), or cream to white (Olsen, 1913; Mead, 1977). In my only relevant observation (a "yawning" juvenile) the bristles were light-colored.

Distribution and Abundance. The seasonal distribution pattern of whales in the principal study area is shown in fig. 4. Table 2 is a monthly summary of aerial and surface sightings.

In January and February whales are very scarce in the area, perhaps absent. A sighting of what most likely was a feeding group of eight or more Bryde's whales off Grenada (West Indies) in January 1979 and reports for January and February from Isla Tortuga suggest that in those months the population remains offshore (and eastward) of the study area.

Early in March the whales moved gradually into the study area, but were seen only in Region 2 (the shallow waters between Isla Margarita and Peninsula de Araya), where they remained into August. In that month whales began to appear in Region 1, particularly in the area a few miles north of Islas Caracas, where the bottom drops steeply into the Cariaco Trench. In fall whales were rare in Region 2, whereas in Region 1 they were always present near the 100 fathom depth contour north of the mainland coast.

Although fishermen reported that whales are occasionally seen and stranded in Region 3 (the Gulf of Cariaco) I never sighted a whale there. With two exceptions (one sighting northwest of Grenada in January and one east of Margarita in August), no whales were seen during aerial and boat surveys in the peripheral region.

All available data (including the present investigation, the preliminary surveys, and interviews with fishermen) indicate that the described distribution is a consistent pattern from year to year.

Aerial and boat surveys (table 2) indicate that whale density is always low in the study area. A whale watching program, manned in Punta de Piedras by students of the Fondacion de la Salle, corroborates this: in over two months of regular observations (March to April 1979) only two whales were sighted. The sample size of whales sighted from the air is too small to attempt absolute or even relative density estimates. Furthermore, the aircraft's high speed (165 km/h) and the whales' long submergence times (often above 10 min) make the probability of sightings very low. Often, during ideal visibility conditions, I saw no whales from the air, even though I had shortly before seen several from the boat in the same location. I am convinced that aerial observation is inadequate for censusing low-density populations of great whales and is much less effective than boat surveys.

Data from the jetfoil survey provide a rough indication of the increase of whales in the area from February through September. The total number of whales sighted each month in the two years was divided by the total number of km traveled in that month (fig. 5). To adjust for the differences between the 1978 and 1979 routes, sightings made in 1978 east of the meridian of Punta de Piedras were subtracted from the total, and the distance traveled from that meridian to Porlamar was also subtracted from the total effort. It is apparent that there are rapid increases of whales between March and April and between August and September. The second increase may actually be a bias due to the westward shift of the whales' distribution in this period of the year. My own observations suggest that peak abundance is in fall and that whale numbers are already decreasing in December.

It is not clear how long individuals stay in the area. During the radio-tracking experiments, both tagged whales disappeared soon after being tagged, and even airplane searches with both radio and visual reconnaissance failed to locate them within a 100 km radius two days after tagging (Watkins et al., 1979). Conspicuous identifying features, such as distinctive color patterns and dorsal fin shape made it possible to recognize individuals, but I never could observe the same individual on two different days. This would suggest that whales enter the area in small numbers, stay for a short period, and then leave. Alternatively, if the whales' home range is much larger than the area arbitrarily chosen for study, movements between food patches would make sighting the same individual on different days improbable.

Herd Size. Fifty-five per cent of all whale sightings were of single individuals, 27% of pairs; herds of more than two accounted for the remaining 18%.

Herd size varied with season (fig. 6). All sightings between March and mid-June were of singles. After 12 June grouping began to be observed, with occasional sightings of pairs, some of them probably cow and calf. Groups of 4 to 5 were observed between late July and October, and up to 7 in November. A sighting of 8 or more rorquals feeding off Grenada in January is not included here because of uncertain species identification.

Behavior. Bryde's whales enter the area to feed. About one third of my observations involved animals engaged in feeding. Non-feeding whales were traveling, presumably between food patches, or resting.

Feeding. Although fishermen state that whales occasionally feed on swarms of planktonic crustaceans ("camaroncito"), all my observations involved feeding on schooling fishes, probably clupeids and engraulidids. Bryde's whales are reported to feed occasionally on fishes of an unusually large size for balaenopterids: "mackerel one foot or more in length" (Olsen, 1913), *Scomberesox saurus* (Best, 1967), sharks of a length of more than two feet" (Olsen, 1913), and carangids (Best, 1977). On one aerial survey I observed a whale pursuing a school of large fishes, perhaps scombrids or carangids, approximately 50 to 100 cm long.

Two feeding patterns were observed: 1) approaching the surface at a steep angle, trapping the prey against the surface and emerging with the mouth wide agape and, 2) approaching a fish school horizontally, sometimes rolling on the side or twisting the body while chasing the fast-swimming prey.

Feeding whales were almost always associated with other vertebrate species also engaged in feeding, presumably upon the same prey. In the neritic habitat of Region 2, feeding whales were seen with pelicans (*Pelecanus occidentalis*), cormorants (*Phalacrocorax olivaceus*) and terns (*Sterna* spp.). In the pelagic habitat of Region 1 the associated species were chiefly common dolphins (*Delphinus delphis*), brown boobies (*Sula leucogaster*) and sailfish (*Istiophorus platypterus*), but occasionally included other booby species (*Sula dactylatera* and *S. sula*), frigate birds (*Fregata magnifens*), terns (*Sterna* spp.), unidentified storm petrels and swallows, blue marlins (*Makaira nigricans*), several elasmobranchs (hammerhead, thresher and carcharhinid sharks); and tuna (personal observations, W. E. Evans and J. R. Jehl, Jr., personal communication).

Diving and Swimming. Figure 7 shows a whale's respiration pattern during a 2 hour and 9 min period. Between dives that lasted for 3 to 11 minutes, the whale blew 7 to 12 times, the series of blows lasting from 2 min 21 sec to 3 min 56 sec. Throughout the observation this whale, a cow with a calf, cruised slowly within an area of about 4 km^2 near the 100 fathom depth contour north of Islas Caracas. The pattern of a number of short dives followed by a prolonged one shown in fig. 7 is consistent with most of my observations. It may be described as follows:

"short dive":

1. As the blowhole ridge breaks the surface, the blow is made. The tip of the rostrum is seldon exposed above the surface.

2. The area posterior to the blowhole follows, gently skimming the surface in the forward motion. Usually very little of it is exposed.

3. The top of the dorsal fin appears, simultaneously with the sinking of the blowhole ridge. The dorsal fin may completely clear the water.

4. The dorsal fin sinks and is the last part of the whale's body seen.

"long dive":

1. The blowhole ridge breaks the surface more forcefully, the blow is usually high and visible. Sometimes the tip of the rostrum is briefly exposed. The whale often appears to increase speed slightly.

2. The back is arched, exposing the sides to a large extent. The anterior part of the body is projected downwards at a steep angle.

3. The dorsal fin is submerged while much of the caudal peduncle is still exposed. The dorsal ridge of the peduncle is the last part of the body seen. The tail flukes were never seen lifted out of the water.

Breaching was observed only once, by a whale that had just been radio-tagged. No spontaneous breaching was seen, although I had several reports from local fishermen of this behavior.

Reproduction. It is not apparent from my data whether this area is a breeding ground. Possible courtship behavior was observed only once, in October 1979: two large whales were swimming in parallel, at touching distance from each other; one repeatedly rolled on its side and presented its ventral surface to the other.

Fishermen reported that cow/calf pairs are not uncommon, and 22% of whales sighted included pairs that I considered to be a cow and calf because of size (one always at least twice as long as the other) or behavior (bodily contact, the smaller whale hiding underneath the larger one, etc.) (fig. 8).

My observation of calves of different sizes at the same time of year (October) may indicate that this population, like the inshore form reported by Best (1977), has an unrestricted breeding season, but there are not enough data to confirm it.

CONCLUSIONS

The productivity of the seas adjacent to Isla Margarita is relatively high compared with that of surrounding regions. Bryde's whales are apparently attracted into the area by the abundance of food. Their density is low, probably due to the fact that, unlike other balaenopterid species, *Balaenoptera edeni* often subsists on relatively large, carnivorous prey, and therefore ranks higher in the trophic chain.

Although the usual prey of Bryde's whales are of local commercial importance, I found no indication of serious competition between man and whales, perhaps because fishery resources appear to be still largely unexploited by locals. Fishermen expressed no animosity against whales, even as perpetrators of damage to fishing gear. Increasing boat traffic, frequent oil spills and offshore oil drilling which is now beginning in that region are more likely to affect the whale population. A proposed bridge connecting Isla Margarita to the mainland coast near Chacopta by way of Isla Coche could constitute a barrier blocking what I believe is the most likely route of access to the area for the whales. But there are many more questions concerning the biology of Bryde's whales and their movement patterns through the area that need to be answered before the impact of human activities on this whale population can be reliably assessed.

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Table 1. Distribution of *Balaenoptera edeni*.

LOCALITY	REFERENCE
General review	Best 1960, 1975, 1977; Gambell 1977; Omura 1959; Soot-Ryen 1961.
Pacific Ocean	
- general	Privalikhin and Berzin 1978.
- northern	Kawamura and Satake 1976; Nemoto and Kawamura 1977; Ohsumi 1977; Tillman 1978.
- northwestern	Nasu 1966; Omura 1959, 1962b, 1966, 1977; Omura and Fujino 1954; Omura et al. 1952.
- northeastern	Balcomb 1974; Kellogg 1931; Leatherwood et al. in press; Morejohn and Rice 1973; Rice 1974, 1977.
- southwestern	Gaskin 1968, 1977; Dixon 1970.
- southeastern	Aguayo 1974; Clarke and Aguayo 1965.
Indian Ocean	
- northern	Pilleri and Gihr 1975.
- northwestern	Al-Robbae 1969; Coustea and Diole' 1972; Mahdi 1967; Roberts 1977; Tadjalli-Pour 1975.
- northeastern	Anderson 1878; Andrews 1918; Berry et al. 1973; Harrisson and Jamuh 1950; Junge 1950.
- southwestern	Olsen 1913; Best 1960, 1974, 1975, 1977.
- southeastern	Chittleborough 1959.
Atlantic Ocean	
- northwestern	Anonymous 1925, 1977; van Bree 1975; Cagnolaro and Notarbartolo di Sciara 1979; Evans et al. 1979; Harmer 1928; Leatherwood et al. 1976; Mackintosh 1946; Mead 1977; Mitchell and Kozicki 1974; Norman and Fraser 1937; Rice 1965; Soot-Ryen 1961.
- northeastern	Anonymous 1950; Cadenat 1955, 1957.
- southwestern	Omura 1962a.
- southeastern	Best 1960, 1974, 1975, 1977; Olsen 1913; Ruud 1952.

Table 2. Summary of whale sightings. In parentheses the number of whales sighted.

Month	Airplane	Boat	Total
January	0	0	0
February	0	0	0
March	2(2)	3(3)	5(5)
April	5(5)	0	5(5)
May	2(2)	0	2(2)
June	7(11)	0	7(11)
July	8(9)	0	8(9)
August	5(7)	3(3)	8(10)
September	5(9)	5(8)	10(17)
October	1(2)	11(29)	12(31)
November	5(8)	6(18)	11(26)
December	3(6)	2(3)	5(9)
Total	43(61)	30(64)	73(125)

FIGURE CAPTIONS

Fig. 1. The study area.

Fig. 2. Distribution of Bryde's whales (sources: 1. Anonymous, 1925; 2. Harmer, 1928; 3. Soot-Ryen, 1961; 4. Mitchell and Kozicki, 1974; 5. Evans et al., 1979; 6. Cagnolaro and N. di Sciara, 1979; 7. Caldwell, 1973; 8. Slipjer and van Utrecht, 1959; 9. Fukuoka, 1967; 10. Gines, 1972).

Fig. 3. Some characteristics of Bryde's whales: the rostral ridges (left) and the variability of the dorsal fin shape (right).

Fig. 4. Seasonal distribution of whales in the principal study area.

Fig. 5. Relative abundance of whales, February through September. Data from Jetfoil survey.

Fig. 6. Monthly variation of mean herd size. The number of sightings on which the calculations are based are reported above each bar.

Fig. 7. Respiration pattern of a Bryde's whale.

Fig. 8. A Bryde's whale cow with calf.

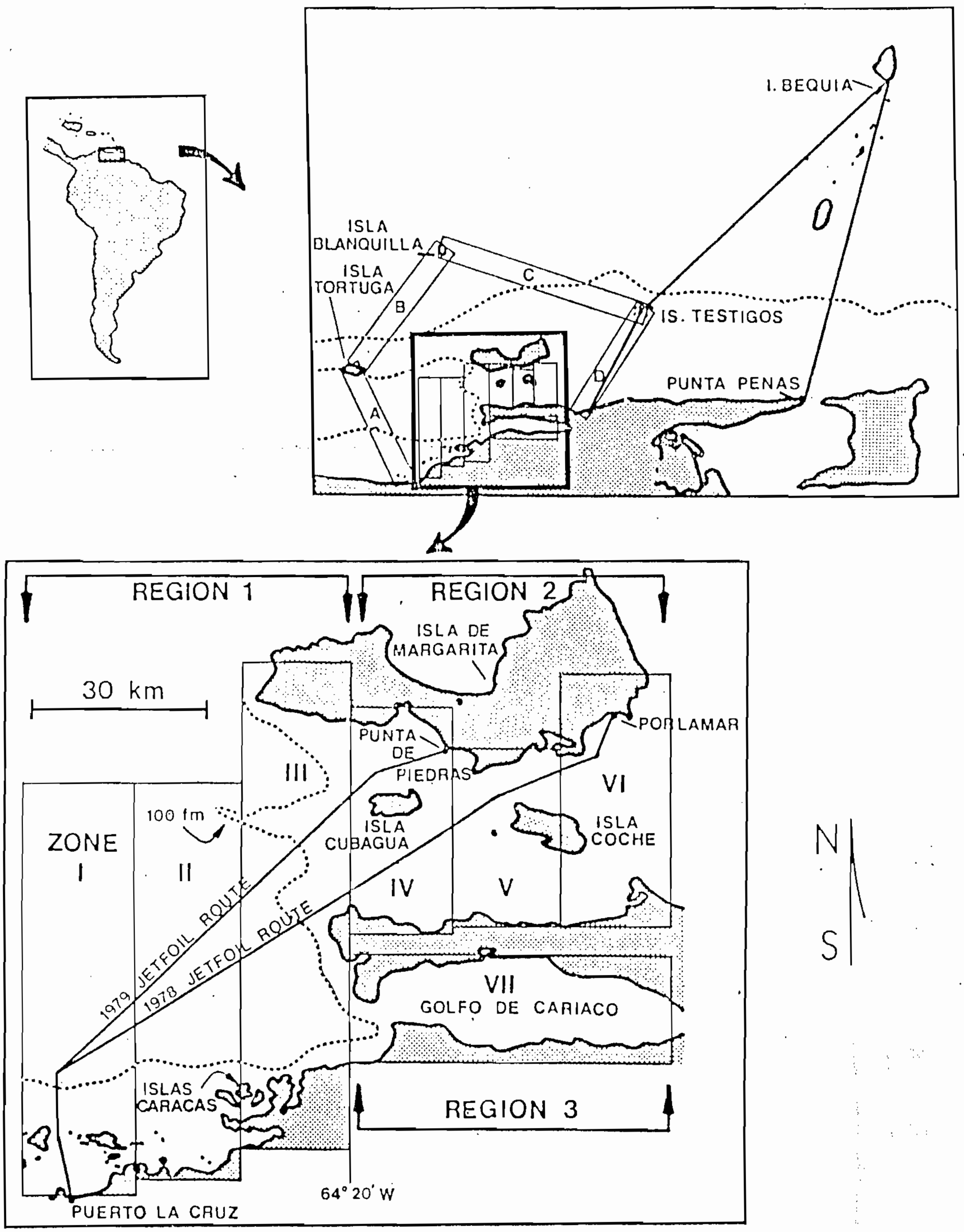

I. BEQUIA
ISLA
BLANQUILLA
ISLA
TORTUGA
B
C
A
D
IS. TESTIGOS
PUNTA PENAS
REGION 1
REGION 2
ISLA DE
MARGARITA
30 km
PORLAMAR
PUNTA
DE
PIEDRAS
III
VI
100 fm
ISLA
CUBAGUA
ISLA
COCHE
ZONE
I
II
IV
V
1979 JETFOIL ROUTE
1978 JETFOIL ROUTE
VII
GOLFO DE CARIACO
ISLAS
CARACAS
REGION 3
64° 20' W
PUERTO LA CRUZ
N
S

FIGURE 1.

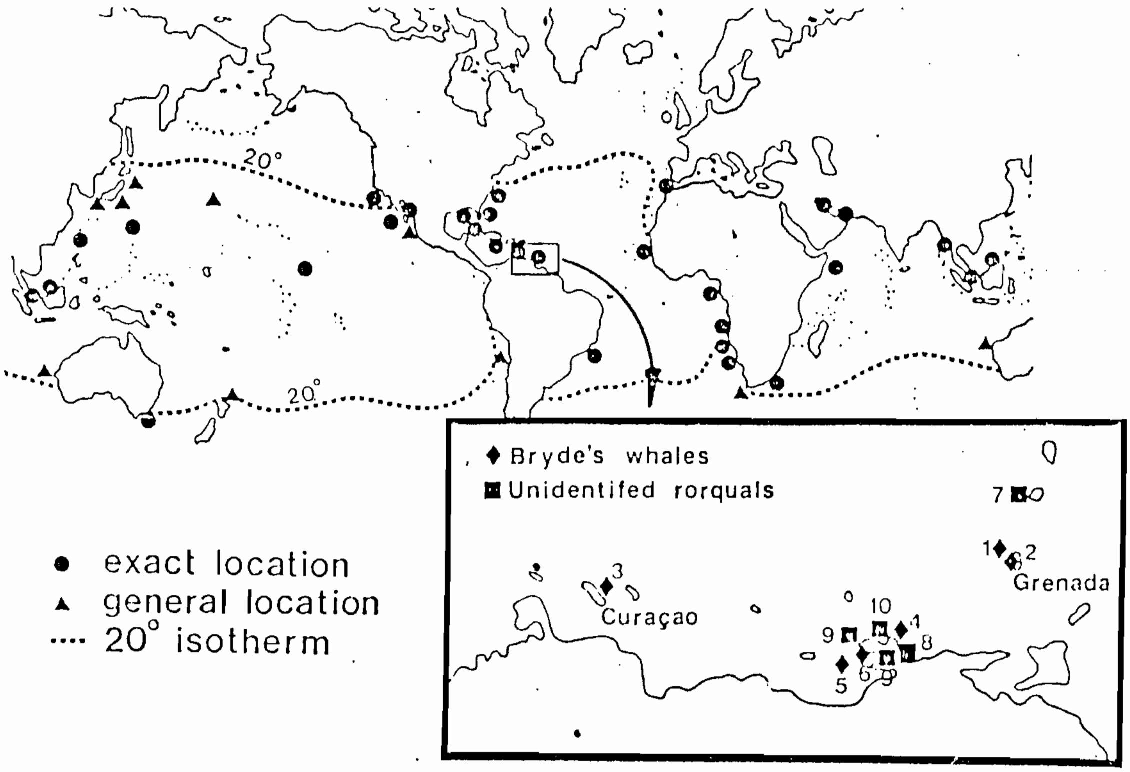

20°
20°
Bryde's whales
Unidentifed rorquals
Curaçao
Grenada
exact location
general location
20° isotherm

FIGURE 2.

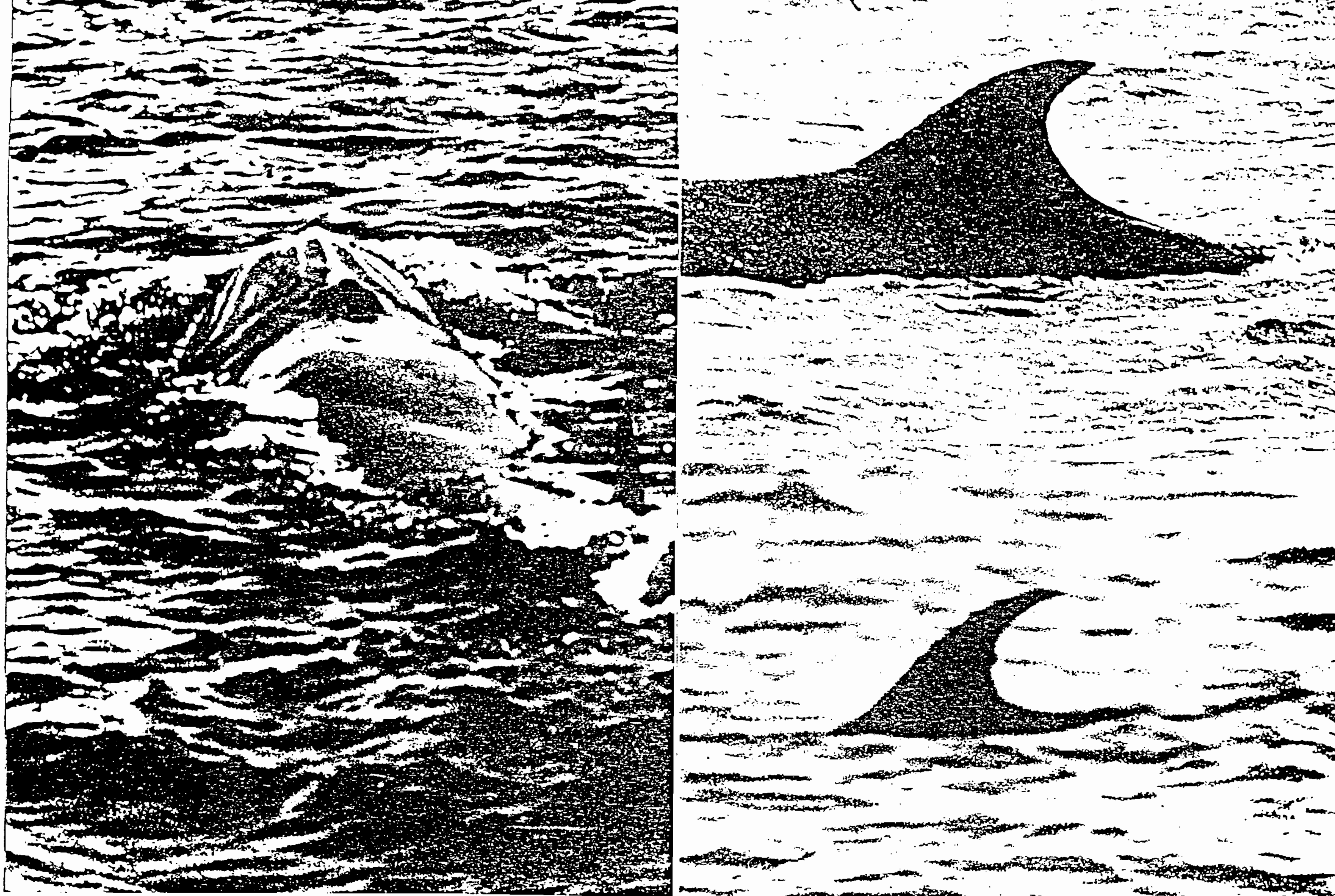


FIGURE 3.

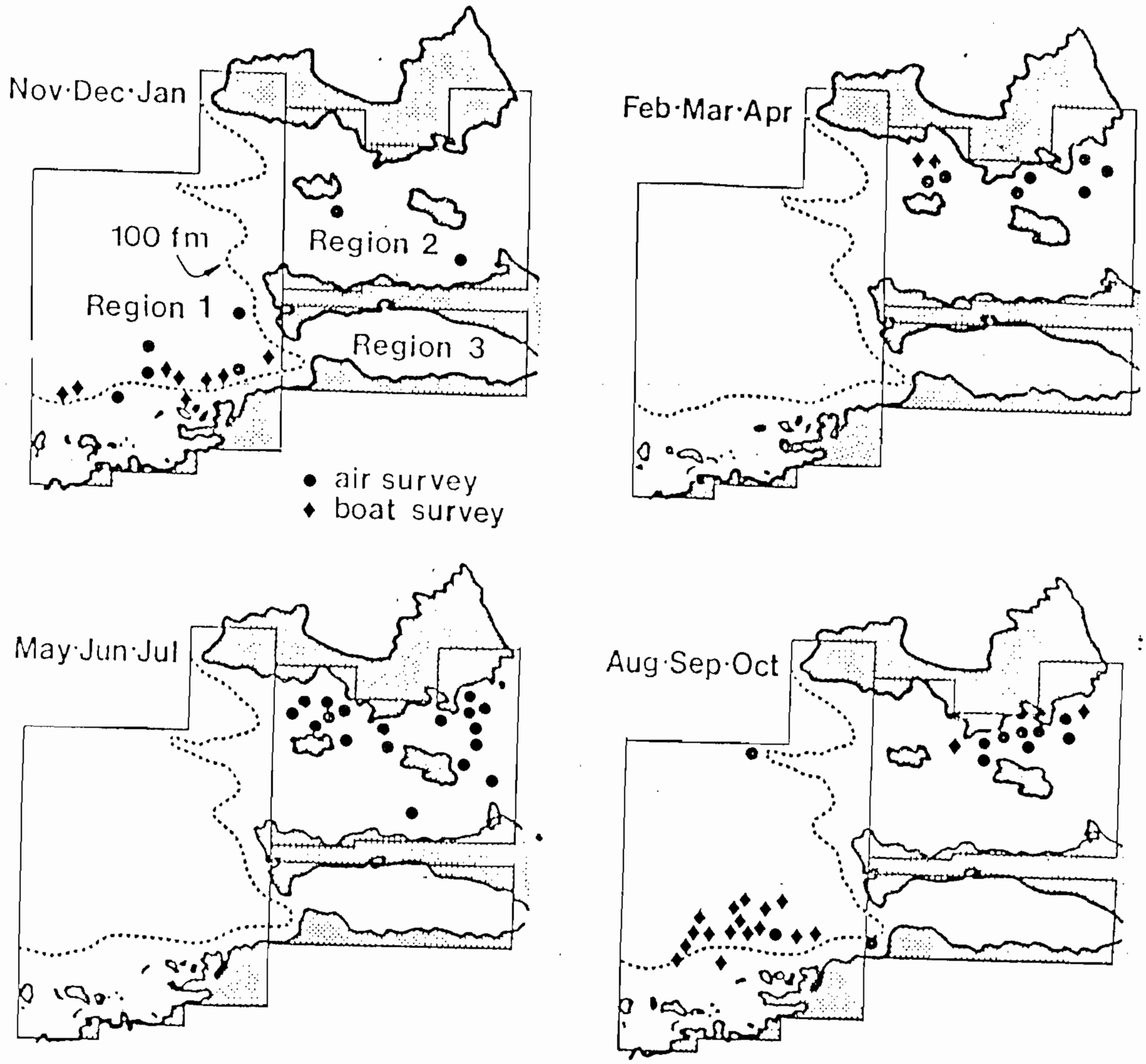
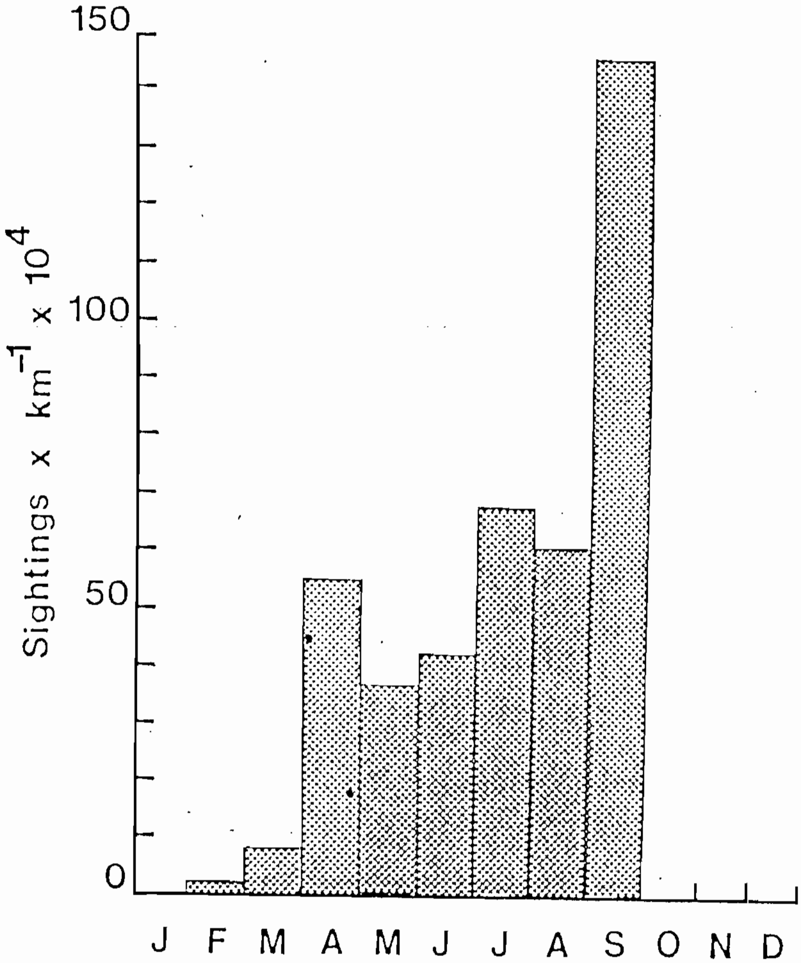

Nov·Dec·Jan
100 fm
Region 1
Region 2
Region 3
air survey
boat survey
Feb·Mar·Apr
May·Jun·Jul
Aug·Sep·Oct

FIGURE 4.



NO. SIGHTINGS	....	4	23	116	83	108	127	83	99	....	....	...
KM* TRAVELED	....	1.40	3.05	2.09	2.25	2.51	1.83	1.36	0.68	....	....	...

*(x 10^4)

FIGURE 5.

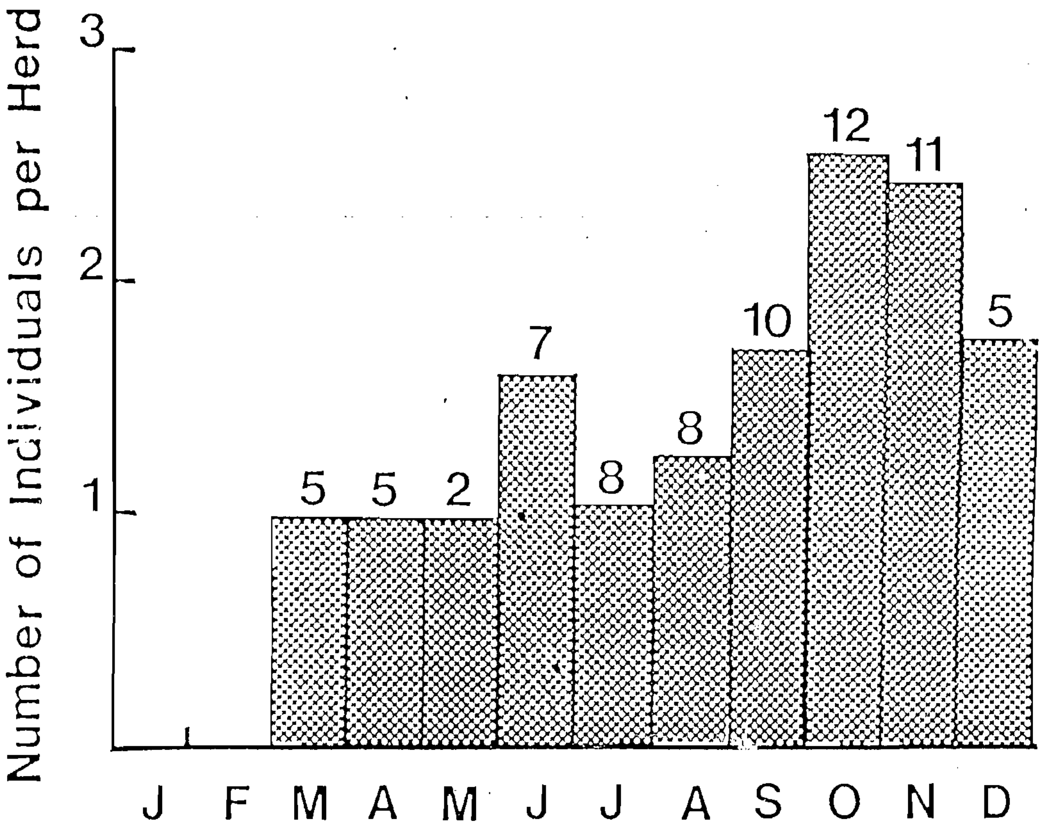

Number of Individuals per Herd
3
2
1
5
5
2
7
8
8
10
12
11
5
J
F
M
A
M
J
J
A
S
O
N
D

FIGURE 6.

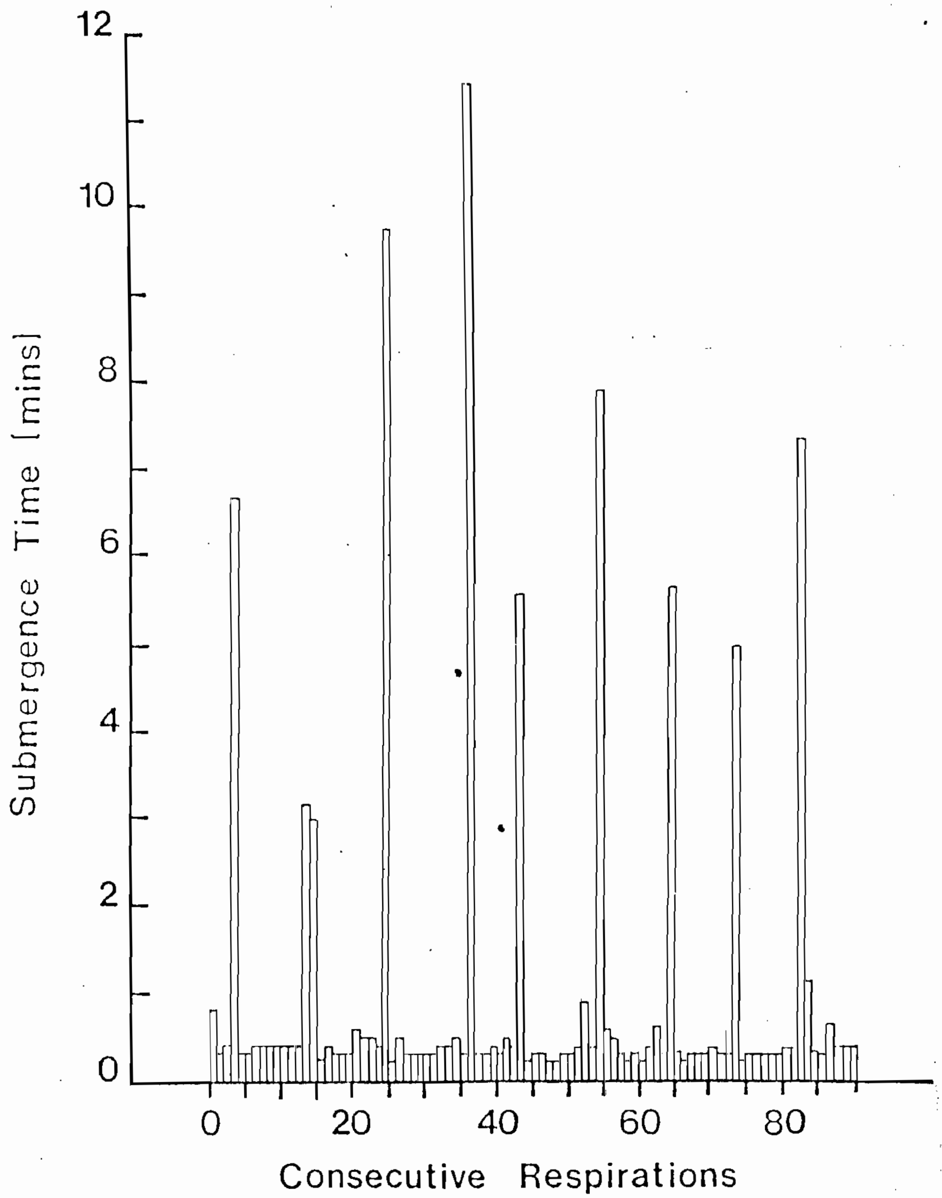

12
10
8
6
4
2
0
Submergence Time (mins)
0
20
40
60
80
Consecutive Respirations

FIGURE 7.

FIGURE 8.