ECOLOGY OF THE ATLANTIC BOTTLENOSED DOLPHIN (*TURSIOPS TRUNCATUS*) IN THE PASS CAVALLO AREA OF MATAGORDA BAY, TEXAS

A Thesis

by

JODY ANN GRUBER

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in partial fulfillment of the requirements for the degree of

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Approved as to style and content by:

(Chairman of Committee)

(Member)

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(Head of Department)

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ABSTRACT

Ecology of the Atlantic Bottlenosed Dolphin (*Tursiops truncatus*)
in the Pass Cavallo Area of Matagorda Bay, Texas. (May 1981)
Jody Ann Gruber, B. A., University of Texas at Austin
Chairman of Advisory Committee: Dr. David J. Schmidly

Atlantic bottlenosed dolphins (*Tursiops truncatus*) were observed from a small boat and from a variety of shrimp boats and land observation points for a total of 15 months in the Pass Cavallo area of Matagorda Bay, Texas. Estimated dolphin density varied throughout the year within the 75 km^2 study area , peaking at 1.29 ± 0.161 *Tursiops*/km^2 in February 1979 and declining to 0.396 ± 0.094 *Tursiops*/km^2 during the following April (± values equal 1 SD about the mean).

Twenty dolphins having unique dorsal fins, scars, or discolorations ("natural tags") were monitored to provide information on home range utilization, daily and seasonal movements, social composition, and behavior. "Naturally tagged" dolphins appeared to belong to one of three extended herds, each with its own extended herd home range. General utilization of particular regions of the study area according to season was apparent. Although several of the "natural tags" appeared to be resident dolphins, sightings were too infrequent to preclude movement outside the study area.

The extent of movement which occurred during time periods of similar length was extremely variable. The majority of encounters involving sightings of the same animal within a 3-day period were plotted less than 5 km from the previous location, although one dolphin traveled 95 km within a similar time period. Daily movements were significantly influenced by both tidal flow and time of day, and significant movement against the tidal flow was found.

Eighteen of the "natural tags" were observed in the company of one or more other "natural tags" from one to 15 times, with a mean of 5.3 times. Pod composition was fluid and dynamic, and "naturally tagged" dolphins interacted with the same individuals over time as well as with a variety of unidentified dolphins. Mean pod and herd sizes varied from two to four animals, and from 11 to 15 animals, respectively. Significant differences ($p < 0.05$) were found between herd size and study area section.

Calves constituted 7.21% of all sightings of Tursiops during the year. Lowest calf percentage was recorded in December 1978 (5.07%) and the highest calf abundance was seen during June 1979 (9.21%).

Observations of bottlenosed dolphins associating with shrimp boats were conducted throughout the year. Feeding ecology, sociality, behavior, movement patterns, and interspecific interaction appeared to be influenced by the dolphins' attraction to shrimp boats.

Three Tursiops within a 45 km^2 region of the study area were infected with Lobomycosis. These dolphins, including one "natural tag" which was monitored for 12 months, constitute the first reported incidents of Lobomycosis in the western Gulf of Mexico.

Twenty-three cetaceans, including four harpooned delphinids, were reported stranded between 15 June 1978 and 31 August 1979. Data on length, sex, possible cause of mortality, and stomach contents were gathered whenever possible.

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I wish to express a most sincere thank you to Dr. Jim Teer for granting me the opportunity to undertake this project. His friendship and interest in my progress throughout these years have been deeply appreciated. As leader of the Caesar Kleberg Research Program in Wildlife Ecology, he supplied both a project boat and funds with which to operate it.

I thank my Committee Chairman, Dr. David Schmidly, for his encouragement and support throughout all phases of my coursework and research. I am most grateful for his prompt and helpful critical review of the manuscript.

I would like to thank Dr. Jack Inglis, committee member, for his interest in my work, his perseverence in locating equipment, and his helpful visits to my study area. I extend my deepest gratitude to him for his guidance and long hours of discussion.

Dr. John Wormuth, committee member, devoted much time to a careful and thorough review of the manuscript, and I am grateful for his helpful suggestions, ideas, and advice.

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Last, I thank the enchanting dolphins for allowing me the privilege of spending 15 months with them and for drawing me back time after time again.

DEDICATION

This thesis is dedicated to my family, first and foremost, to my parents, Haskell and Rosalind Gruber. They have always been ready and eager to help, love, encourage, and give their all to me, no matter what the circumstance or price. They have been strong enough to set me free to pursue everything I have ever desired and have stood beside both me and all the wishes, intentions, dreams and schemes that have taken me to distant shores and souls yet have drawn us so close to one another...dedicated to my sister Wendy, brother-in-law Maury, and bright-star Alissa, who gave me their home during those long months when I needed its peace and companionship, warmth, and quiet the most...dedicated to my brother Nelson, who, with or without words, always understood so well, and whose Saturday night pep talks kept me tough and fighting.

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INTRODUCTION

The Atlantic bottlenosed dolphin, Tursiops truncatus, is familiar to the public as a performer in oceanaria throughout the world. This species has been successfully maintained in captivity for over 60 years (Townsend, 1914a), and a multitude of studies have examined its physiology and ethology under confined conditions. However, the use of captive studies as the sole means of interpreting the behavioral repertoire, physiology, and sociality of bottlenosed dolphins must be viewed with circumspection. Results obtained under artificial conditions with unnatural combinations of animals may not be representative of natural conditions. Even so, relatively little attention has been focused upon the ecology and population biology of free-ranging Tursiops. Only during the past decade has emphasis been placed upon initiating intensive, localized studies in conjunction with consistent, recurrent aerial surveys.

One study by Shane (1977) and Shane and Schmidly (1978) has been conducted in Texas waters. This intensive, year-long study is the only one of its kind to investigate a local stock of dolphins in an area along the Texas coast, or, for that matter, in the entire western Gulf of Mexico. The Texas coast extends for over 1000 km and its habitat complexity and degree of man-made development and exploitation are diverse. Because the nature of distribution and habitat utilization by Tursiops throughout Texas bay systems is largely unknown, accurate comparisons among areas cannot be made, and generalizing from Shane (1977) and Shane and Schmidly's (1978) findings to other coastal areas may be unfeasible. The paucity of data regarding the status of Tursiops truncatus in the western Gulf of Mexico, combined with the active live-capture fishery for dolphins, dolphin-commercial fishery conflicts, unknown effects of in- and offshore energy development,

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The style followed in this thesis is that of the Journal of Mammalogy.

pollution and traffic, elucidate the need for continued research concerning the population biology and ecology of this species.

The objectives of this study were to investigate the following aspects of the ecology of *Tursiops truncatus* in the Pass Cavallo area of Matagorda Bay, Texas: (1) population density, (2) home range, (3) daily and seasonal movements, (4) social composition, (5) the association of *Tursiops* with shrimping activity, and (6) strandings.

LITERATURE REVIEW

Bottlenosed dolphins have been successfully maintained in captivity since 1914 (Townsend, 1914a, 1914b, 1915). The literature pertaining to their ethology and physiology under confined conditions is abundant. Several long-term behavioral investigations are classic studies (McBride, 1948; McBride and Hebb, 1948; McBride and Kritzler, 1951; Essapian, 1963; Tavolga and Essapian, 1957; Tavolga, 1966), and, more recently, Ridgway and Benirschke (1977) summarized the knowledge of captive *Tursiops* on a worldwide basis.

Accounts of free-ranging *Tursiops* are far more limited. Early reports consisted of largely opportunistic field observations (Gunter, 1942; Moore, 1953; Brown and Norris, 1956; Norris and Prescott, 1961; Layne, 1965; Caldwell et al., 1965; Brown et al., 1966). Only during the last decade have investigations of free-ranging *Tursiops* emerged in the nature of deliberate, detailed studies based on boat, aircraft, or land observation techniques. Irvine and Wells (1972) presented preliminary findings regarding movements and social structure of tagged bottlenosed dolphins, and Asper and Odell (1980) captured, cryogenically marked, and later resighted 25 dolphins in the Indian and Banana Rivers on the east coast of Florida. Leatherwood and Platter (1975), Barham et al. (1980) and Odell and Reynolds (1980) aerially surveyed *Tursiops* in several regions of the Gulf of Mexico, and Saayman et al. (1972, 1973) and Saayman and Tayler (1973) conducted shoreline observations of Indian Ocean bottlenosed dolphins (*Tursiops aduncus*) and humpbacked dolphins (*Sousa*) on the southeastern Cape coast of South Africa.

Few long-term studies of *Tursiops* within localized areas have been conducted. Hogan's (1975) thesis draft described several months' observations of the movements, group composition, and behavior of the species at the mouth of the Savannah River along the South Carolina and Georgia coastlines. Shane (1977) and Shane and Schmidly (1978) conducted an intensive, year-long investigation of the population biology of *Tursiops* in the Aransas Pass area of Texas. Würsig and Würsig's (1979) 21-month study focused on the ecology and behavior of *Tursiops* off the Argentine coast, and Irvine et al. (1979) captured, tagged, and released 47 dolphins during their 18-month field study of the movements and activities of Tursiops in Florida.

These investigations, in conjunction with short-term studies and opportunistic observations, have begun to lay the foundation from which to continue accumulating baseline data on the natural history and ecology of Tursiops truncatus. The following sections will primarily focus upon bottlenosed dolphins in the Gulf of Mexico.

Distribution

The bottlenosed dolphin, distributed throughout tropical and temperate waters of the world (Rice, 1977), is found in the coastal waters of the Gulf of Mexico, where it inhabits the bays, channels, lagoons, and marshlands. There have been reports of dolphins ascending several kilometers up rivers although greatest numbers are present near the passes which connect the large bays to the Gulf (Lowery, 1974). In the Gulf, they are often found just beyond the surf and may be seen several kilometers offshore, ranging as far as the 200-m curve. Dolphins living offshore may represent a separate stock that is larger and harbors a different parasite load than do inshore animals (Winn et al., 1979). The inshore population is possibly divided into two subgroups, the first being confined to near-shore Gulf waters ("ocean" porpoises) and the second being restricted to inlet, lagoon, and confined salt water river waters ("river" porpoises) (Winn et al., 1979). The extent to which these subgroups intermingle is unclear. Shane (1977) and Shane and Schmidly (1978) stated that dolphins in their study area mixed quite easily with Gulf dolphins, although the latter were almost never noted entering Aransas Pass.

Home Range and Movements

Bottlenosed dolphins appear to be organized into local populations, each occupying a small region of the coast (Odell et al., 1975). Caldwell (1955) provided the first evidence of a home range for Tursiops;

Caldwell and Caldwell (1972a) later proposed two or more ranges connected by a traveling range. Irvine and Wells (1972), Shane (1977), Shane and Schmidly (1978), and Irvine et al. (1979) found evidence demonstrating the use of home ranges. Wells (1978) observed that individual home range size and location varied with age and sex class.

A certain amount of migration occurs to and from inshore and offshore areas, as well as linearly along the coastline (Odell et al., 1975). Strandings and sightings along the coastline suggest the absence of seasonal migrations of entire populations although localized seasonal movements do seem to occur. Irvine and Wells (1972) recorded fewer dolphins in their study area during the winter than in the summer, and Irvine et al. (1979) noted a distinct difference of habitat utilization according to season. Although Gunter (1942) claimed a lack of seasonal variation in abundance of _Tursiops_ in Texas waters, Shane (1977) and Shane and Schmidly (1978) reported higher winter population counts due to an influx of animals from either the Gulf of Mexico or from adjacent bay systems. Several other authors, including True (1890), Caldwell and Caldwell (1972a), and Hogan (1975) suggested that seasonal movements occur along the Atlantic coast.

Environmental factors including temperature, tide, and time of day apparently influence the daily movements of _Tursiops_. Caldwell and Caldwell (1972a) stated that the local movement of dolphins along the northeastern coast of Florida appeared to be southeasterly in the morning and northwesterly in the afternoon. Irvine and Wells (1972) and Irvine et al. (1979) found that bottlenosed dolphins along the Gulf coast of Florida moved with the tides, although Shane (1977) and Shane and Schmidly (1978) found significant movement against the tidal flow. Hogan (1975), Irvine et al. (1979), Shane (1977), and Shane and Schmidly (1978) observed that _Tursiops_ followed a set pattern of movement for several days or weeks, after which they would abruptly adopt a new pattern.

Social Composition

Groups of over 200 _Tursiops_ have been recorded off the coastal waters of Alabama, Mississippi, and Louisiana (Leatherwood and Platter, 1975). Mean herd sizes vary from one area to another, although Hogan (1975), Shane (1977), Shane and Schmidly (1978), Würsig and Würsig (1977), Würsig (1978), and Irvine et al. (1979) have observed subgroups averaging three to eight animals. Wells (1978) observed group size variation according to season, time of day, water depth, and habitat complexity. Large groups of dolphins were seen in the winter and in deep water, while small groups were noted early in the morning and late in the afternoon. Leatherwood and Platter (1975), Leatherwood et al. (1978b), Shane (1977), Shane and Schmidly (1978), and Irvine et al. (1979) also found larger groups in the more open areas rather than in the constricted marshlands, lagoons, and shallow embayments.

Irvine et al. (1979) identified a population of dolphins in their Florida study area that was composed of one to two discrete social units with several small groups that appeared to be subunits of the larger, socially-interacting herd. Shane (1977), Shane and Schmidly (1978), and Irvine et al. (1979) noted that dolphins seemed to associate with many of the same individuals repeatedly over time, and stated that short-term encounters were also evident, variable, and unpredictable. Irvine and Wells (1972) captured the same three male Tursiops together on three different occasions, and Asper and Odell (1980) observed two freeze-branded males together every one of the nine times in which they were sighted.

Abundance and Status

No all-inclusive population counts are available for the entire Gulf of Mexico, although Prescott et al. (1979), Leatherwood (1979), and Barham et al. (1980) presented density estimates for several regions of the Gulf of Mexico and east coast of Florida. These values range from 0.23 Tursiops/km^2 in Mississippi waters to 0.75 Tursiops/km^2 along the Texas coast. Odell and Reynolds (1980) estimated 0.06 Tursiops/km^2 and 0.12 Tursiops/km^2 in Gulf waters off the Florida peninsula and panhandle.

Hogan (1975) estimated 150 to 300 dolphins in the vicinity of the mouth of the Savannah River, and Shane (1977) and Shane and Schmidly (1978) recorded an increase from 48 to 104 _Tursiops_ in October 1976 to 164 to 281 individuals in January 1977. Irvine et al. (1979) estimated 102 dolphins in their study area along Florida's central west coast.

The above density estimates suggest population sizes that vary from one region to another. Food abundance, habitat type, human activity, and pollution, may account for these differences. Although Caldwell and Caldwell (1972a) stated that population numbers in Florida waters were stable and unaffected by the live-capture dolphin fishery, Odell (1976) suggested that heavy boat traffic in Biscayne Bay, Florida, might be responsible for the scarcity of _Tursiops_ in that area. Few _Tursiops_ in the St. Johns River in Florida correlated with increased commercial shipping. Shane (1977) and Shane and Schmidly (1978) stated that although boat traffic was quite heavy in the Aransas Pass area, it seemed to have no effect upon dolphins in that area. Gunter (1942), Lowery (1974), and Walraven (1976) also claimed that shooting and explosion of seismographic charges in offshore waters were responsible for a decline in dolphin numbers.

Reproduction

Males mature at 2.45 to 2.6 m or 10 to 13 years of age (Sergeant et al., 1973). Females mature at lengths ranging from 2.2 to 2.35 m or 5 to 12 years of age (Sergeant et al., 1973). Gestation in _Tursiops_ is approximately 12 months, with most calving and mating from February to May in Florida waters. A second calving and mating period from September to November may also occur in south Florida waters (Essapian, 1963).

Calves measure from 98 to 126 cm and weigh 9.1 to 11.4 kg at birth (Gunter, 1942; Sergeant et al., 1973). Females have been estimated to give birth to about eight calves in their lifetimes (McBride and Kritzler, 1951).

The percentage of calves in a population is indicative of its reproductive viability, and knowledge of this parameter is important for management purposes. Leatherwood and Platter (1975) reported calf counts of 7.7 to 7.9% of the population in coastal waters off Alabama, Mississippi, and Louisiana during the summer of 1975. Irvine et al. (1979) calculated spring calf counts of 14% near Tampa Bay, Florida. Shane (1977) and Shane and Schmidly (1978) stated that calves constituted 7.61% of the population in the Aransas Pass area of Texas. Calf counts of 8.1 to 10.1% in the Indian and Banana Rivers on the east coast of Florida were reported by Leatherwood (1979), while Barham et al. (1980) recorded 9.3% calves in Texas waters.

Dolphin - Shrimp Fishery Association

Several authors have reviewed food preferences and feeding behavior of Tursiops (True, 1890; Gunter, 1938, 1942, 1943, 1951, 1954; Harris, 1938; Kemp, 1949; Hoese, 1971; Caldwell and Caldwell, 1972a; Hogan, 1975; Leatherwood, 1975; Leatherwood et al., 1978a; Shane, 1977; Shane and Schmidly, 1978). The general consensus is that bottlenosed dolphins appear to be quite flexible in their feeding regimes, preying upon the most abundant of various fishes, molluscs, and arthropods. Leatherwood (1975) concluded that, assuming bottlenosed dolphins are relatively limited in their ranges and engage in relatively short-term movements, plasticity in food habits is essential for survival.

Specific reference to bottlenosed dolphins feeding in conjunction with shrimping operations is more limited. Gunter (1938, 1942, 1954) described dolphins feeding behind working shrimp boats. The attraction of Tursiops to boats from considerable distances away, probably in response to the sounds produced by winching in the nets, was described by Norris and Prescott (1961). Leatherwood (1975) stated that dolphins foraged behind working shrimp boats, fed on trash fish and fed on fish attracted to non-working shrimpers. Shane (1977) and Shane and Schmidly (1978) also described several aspects of dolphins' associations with shrimp boats.

Strandings

Schmidly and Melcher (1974) considered Tursiops the most common delphinid in Texas waters due to the large numbers of beached animals. Schmidly and Shane (1978) stated that *Tursiops* was the most common cetacean in their study area, but did not regard stranding data as a good indication of the relative abundance of cetaceans. Other accounts by Caldwell and Golley (1965), Caldwell et al. (1971), Caldwell and Caldwell (1973), and Mead (1975b) have compiled the records of stranding occurrences along the Atlantic and Gulf of Mexico.

STUDY AREA

The Pass Cavallo area of Matagorda Bay (Fig. 1) (28°22'N, 96°24'W) was chosen as the study site because of a reported abundance of dolphins, its habitat complexity, significant land observation points, and wide spectrum of water-related human activities. The 75 km^2 study area (Fig. 2), located in the southwestern corner of Matagorda Bay and its environs, is comprised of several physiographic areas, including a natural pass, open bay waters, a variety of channels, extensive mud flats and grass beds, and the near-shore Gulf of Mexico.

Physiographic Characteristics

Pass Cavallo, the channel between Matagorda Island and Matagorda Peninsula, exhibits extensive shoaling, and its depth varies considerably over time. The man-made Matagorda Ship Channel cuts through Matagorda Peninsula 6 km northeast of the Pass. It has been dredged an average 11 m deep and 61 m wide throughout its 35 km length. Pass Cavallo and the Matagorda Ship Channel constitute the major avenues of Gulf exchange with the estuarine system. Tankers, freighters, oil company supply boats and crewboats, shrimp boats, and recreational small craft regularly use the Matagorda Ship Channel, while Pass Cavallo is primarily limited to small craft.

The largest portion of the study area, approximately 58 km^2, consists of the open waters of Matagorda Bay northwest to the harbor of Indianola, south to Pass Cavallo, northeast to the Matagorda Ship Channel, and northeast along the Matagorda Peninsula shoreline to the Peninsula bulkhead. Mean depth of Matagorda Bay is 3 to 4 m.

The remaining 16.5 km^2 of the study site are contained within an area of marshlands, mudflats and grassbeds, and small embayments. Two marshland channels, Saluria Bayou (6 to 12 m deep) and Big Bayou (3 to 5 m deep) communicate with Pass Cavallo and Matagorda Bay to the northeast and with Espiritu Santo Bay to the southwest. Extensive areas of mudflats, grass beds, and oyster shell lie to the south and

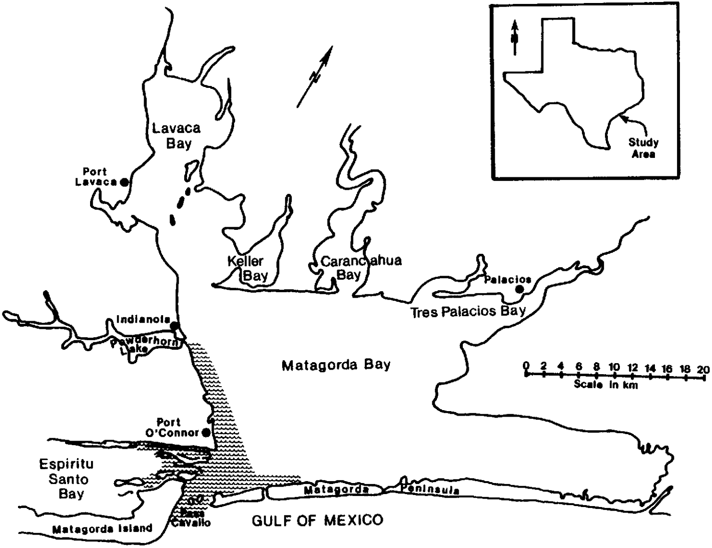


Fig. 1.— Map of the Lavaca-Matagorda Estuarine System of the Texas coast, showing the shaded-in study area.

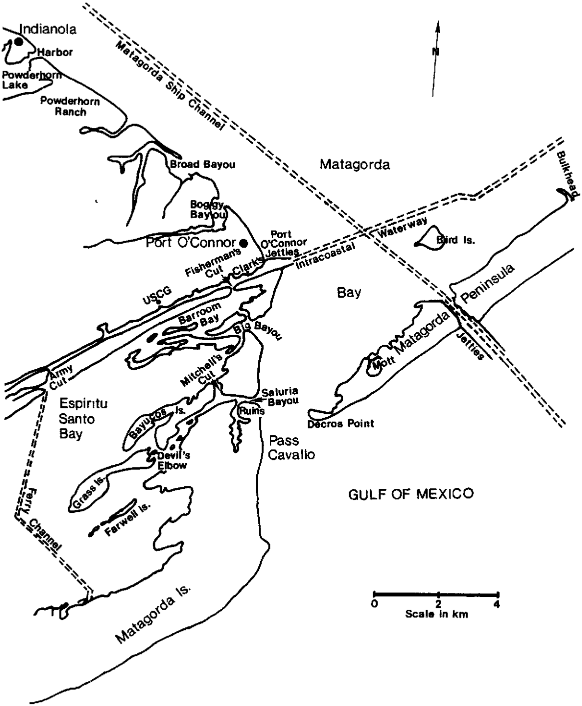


Fig. 2.— Map of the study area in the Pass Cavallo area of Matagorda Bay, Texas.

west of Saluria Bayou and Big Bayou, adjacent to Espiritu Santo Bay. Twelve km of the Intracoastal Waterway intersect the study area at a dredged depth of 4 to 5 m.

Division of the Study Area

The study site was divided into six sections (Fig. 3) which were either distinguished as distinctive physiographic units or could be considered separate from adjacent areas due to the presence of various man-made structures. The division of the study area into these six smaller regions made coverage more manageable and organized, and allowed easy referral to general sites within the entire area.

Each section was further broken down into varying numbers of grids which made it possible to clearly specify which small portions of the area were being investigated or discussed. The study area consisted of a total of 94 grids (Fig. 3).

Land Observation Points

Observations from land points aided in clarifying daily movements and near-shore behavior and were used in conjunction with boat and aircraft-based observations. The six locales (Fig. 3) which were frequented throughout the year included: (1) Decros Point at the far southwestern tip of the Matagorda Peninsula, (2) the U.S. Coast Guard Station ruins on Saluria Bayou, (3) the northeastern end of Matagorda Island, (4) the Matagorda Ship Channel jetties, (5) the ends of the Port O'Connor jetties, and (6) the intersection of Fisherman's Cut and the Intracoastal Waterway.

Vegetation

The Matagorda Bay floor varies from sand or mud off the Matagorda Peninsula to a bottom composed primarily of fine silts and sands in the northwest region of the study area. Small beds of shoalgrass

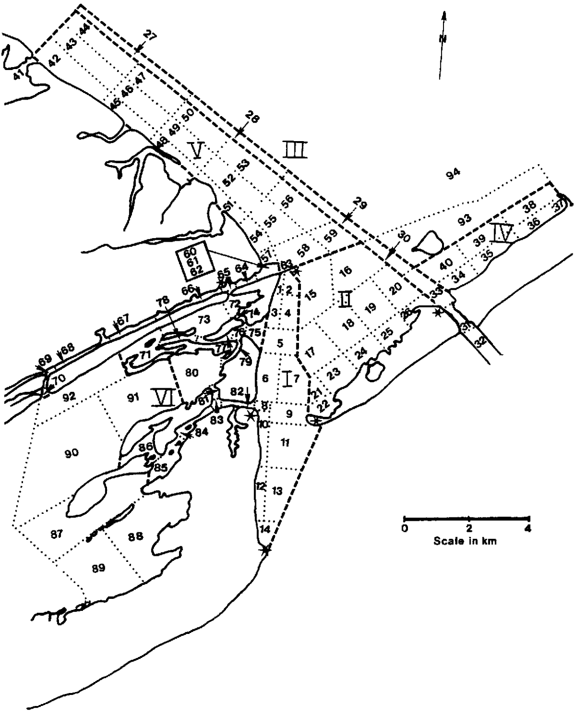


Fig. 3.—The six sections (I-VI) and 94 grids into which the study area was divided. Although grids 87-94 lie outside the study area, dolphin observations were sometimes recorded in those grids. Asterisked areas indicate the six land observation points.

(Halodule wrightii) are found along the shoreline of Section 5, while turtle grass (Thalassia testudinum) is the dominant sea grass species in depths of 1.2 to 1.8 m.

Vegetation in the marshlands consists of submerged smooth cordgrass (Spartina alterniflora) as well as frequently inundated saltwort (Batis maritima). Exposed areas of smooth cordgrass (Spartina alterniflora) and also salt meadow cordgrass (Spartina patens), Gulf cordgrass (Spartina spartinae), and glasswort (Salicornia) commonly occur. Shore grass (Monanthochloe littoralis) is found in the high, drier portions of the extensive marshlands.

Climate

The study area is located in the Southern Plains and Lowlands Climatic Region, which is characterized by mild, humid winters, and warm, humid summers. Table 1 presents the mean air and water temperatures during all four seasons of the study. Seasons were defined as: Fall--September, October, November; Winter--December, January, February; Spring--March, April, May; Summer--June, July, August (Shane, 1977; Shane and Schmidly, 1978).

Prevailing southeast winds are common year-round. However, strong, sudden northerly winds, or "northers", greatly affect the area during the winter months. Following several northers, mean water level in the bays may drop as much as 1 m.

Tides and Currents

The tides in the area are characterized as diurnal and mixed semi-diurnal. The mean diurnal tide range for Matagorda Bay is 0.21 m, and the estimated maximum tidal range is 1.07 m (Federal Power Commission, 1977). Tidal levels and currents may be substantially altered by storms and winds. Tidal fluctuation, most evident in the Matagorda Ship Channel, is also quite apparent in Pass Cavallo, Saluria Bayou, and at the mouth of Powderhorn Lake.

TABLE 1.— Seasonal mean air and water temperatures (°C) during the 1978-1979 study.

	Air	Water
Fall	24.16	24.00
Winter	13.07	13.05
Spring	22.75	21.59
Summer	29.89	29.48

MATERIALS AND METHODS

The summer of 1978 was spent delineating the boundaries of the study area, finalizing observation and census techniques, gathering initial data, and interviewing local shrimpers and fishermen. Data gathered during the initial summer period were not included in the computer analysis, but proved helpful in subsequent comparisons of dolphin movements and distribution. During the one-year study from 1 September 1978 until 31 August 1979, a total of 255 days (1121 hours) was spent observing dolphins (Table 2).

Observation Types and Platforms

A 4.3 m aluminum flat-bottomed boat and 25 horsepower motor served as the main observation platform during the summer of 1978 pilot study. The boat proved to be impractical for covering the open bay waters under a variety of sea conditions, so a more suitable project boat was acquired at the end of August. The 5.2 m tri-hull Falcon Cougar (with 85 horsepower motor) was small enough to maneuver easily among the dolphins and into relatively shallow areas, yet substantial enough to work in rougher water and in the Gulf of Mexico.

The Falcon was the main observation platform, and four types of observations were conducted from it including: (1) census runs, (2) regular boat observations, (3) "following" observations, and (4) shrimp boat observations. Dolphins in each of the six sections of the study area were counted by the zig-zag census technique (Shane, 1977) (Fig. 4). Sections which were predominantly composed of channels were covered by piloting the boat forward at a slow, steady speed and counting dolphins on either side of the boat. In order to cover areas that were much wider, the boat was handled in a slow, zig-zag course that assured total coverage of the whole section. Each of the six sections was censused separately, and dolphin numbers were recorded by section and grid location. Efforts were made

TABLE 2.— Days of observation (total 255) by month and season and hours of observation (total 1121) by day, month, and season.

	Days of Observation		Hours of Observation		
	By Month	By Season	By Season	By Month	Avg./Day
September	22			121	5.50
October	26	64	FALL 328	138	5.30
November	16			69	4.31
December	14			52	3.71
January	14	48	WINTER 184	53	3.79
February	20			79	3.95
March	30			133	4.43
April	20	74	SPRING 297	73	3.65
May	24			91	3.79
June	21			99	4.71
July	24	69	SUMMER 312	90	3.75
August	24			123	5.13

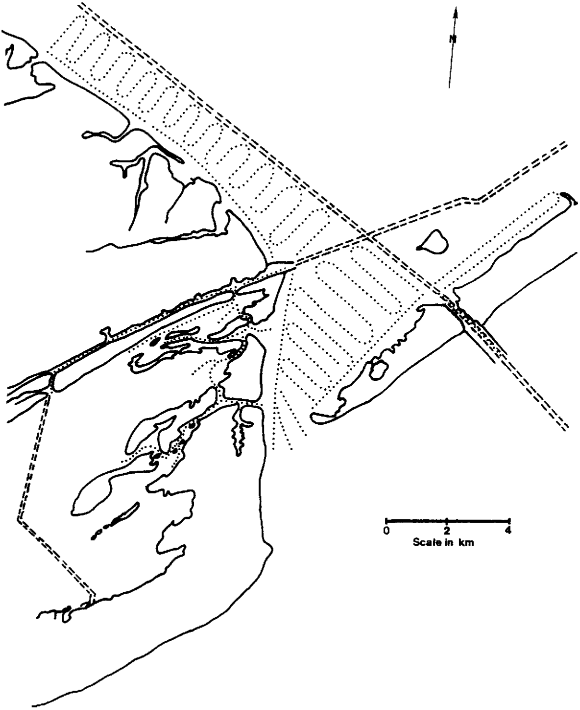


Fig. 4.— Designated routes traveled in each of the six study area sections when conducting "zig-zag" censuses (Shane, 1977; Shane and Schmidly, 1978). Section 3 was covered in the Section 2 and Section 5 patterns.

to census the whole study area on the same day so that a more realistic picture of dolphin numbers and distribution could be obtained. Censuses were conducted several times/month.

Regular observations consisted of driving the boat through different sections of the study area until dolphins were observed. Once dolphins were sighted, the number of animals, general direction of movement, basic group composition, and initial behavior were recorded. Then, either the initial distance was kept and observation continued, or the dolphins would approach the observation platform, or the investigator would approach the dolphins, giving them wide berth and never heading directly into the animals. Individuals were photographed and identified, dolphins were recounted, group composition and distribution were examined more closely, calves were recorded, directional movements and changes were noted, and behavior was closely observed. Observations of these types lasted from a few seconds to over an hour.

If the dolphins were engaged in goal-oriented travel and movement when initially sighted, they were often followed ("Following", Observation Type 3) for several minutes to over 2 hours. Observations of this sort proved helpful in examining daily movement patterns.

The fourth type of observation involved following Tursiops which were associating with shrimp boats both inside and outside the study area. The dolphins followed behind the boats, presumably feeding on fish and other organisms either caught in the net or stirred up as it was towed along the sea floor. They also approached shrimp boats in order to feed on the trash fish that were culled out from the shrimp and thrown overboard. Several days of observations were made from shrimp boats; however, the project boat was considered the superior observation platform. It allowed more freedom to closely approach dolphins; to travel back and forth among several shrimp boats so that dolphin numbers, group composition, and behavior could be compared; to observe feeding at close range; and to follow departing dolphins in order to note subsequent movement and activities. A total of 97 hours of shrimp boat-related observation during the fall, late spring, and summer was made aboard the 5.2 m Falcon.

The second observation platform was the 14.7 m shrimp boat, the

"Capt. Morocco" of Port O'Connor. The majority of observations were conducted during the fall and spring shrimping seasons (15 August to 15 December, 15 May to 15 July) in the study area, as well as in other areas of Matagorda Bay and the Gulf of Mexico. A total of 16 days during September and October 1978 and March through July 1979 was spent aboard the "Capt. Morocco". Dolphins associating with the shrimp boat could be seen throughout the day. Their interaction with the shrimp boat and trawl during all stages of the shrimping operation could be viewed without disturbing them; also, night feeding and milling patterns around the shrimp boat could be studied.

The third observation platform was land. Although observations from land were conducted whenever possible, they were made more on an opportunistic than regular basis. Observations were recorded from all six land points during all four seasons, but emphasis on this observation type was secondary.

Aerial observations were made on several occasions. Three surveys of the study area were conducted on 10 August 1978, 30 September 1978, and 16 October 1978 from a Piper Cub PA 11. Five observations from helicopters (Petroleum Helicopters, Inc. and Evergreen Helicopters) were made on 11 December 1978, 18 December 1978, 14 January 1979, 25 February 1979, and 7 March 1979. Follow-up surveys (Cessna 172 Skyhawk) of dolphins in several regions of the study area were undertaken during May, August, and November 1980, and February 1981 when the investigator was involved in several days of National Marine Fisheries Service (NMFS) aerial surveys along the Texas coast.

Interviews

Discussions and interviews contributed a vast amount of essentially subjective information regarding the movements, habits, and areas of greatest concentrations of bottlenosed dolphins. Local residents, shrimpers, commercial and sports fishermen, fishing guides, marina owners, oil rig workers, crewboat employees, and aircraft personnel provided assistance. An excellent rapport was maintained with area shrimpers who permitted the investigator to accompany them on their boats, shared their opinions about dolphins and shrimping, informed the investigator of stranded animals, and notified the investigator of any instance in which a dolphin was caught in a shrimp trawl. These informal discussions led to the eventual distribution of a questionnaire which aimed to gather more detailed information about dolphins and shrimpers.

Strandings

Signs requesting information about distinctively marked dolphins, unusual behavior, and strandings were posted in Port O'Connor and in the neighboring towns of Seadrift and Indianola (Fig. 5). Aside from publicizing the study, the posters proved most helpful by providing a person to contact in the event of stranded cetaceans.

The majority of reported strandings occurred in the study area or within a 20-km radius of Pass Cavallo. Accessible stranded animals were photographed and measured (Norris, 1961) and efforts were made to determine possible causes of death. Five skulls were transferred to Texas A&M University, and teeth taken from four dolphins were used for age identification. Records of all stranded cetaceans were sent to Edward Smith, Jr., National Oceanographic and Atmospheric Administration (NOAA), Department of Commerce, who forwarded the copies to the Smithsonian Institution.

Equipment

Field notes were taken on a portable cassette tape recorder. The notes were later transcribed verbatim, and then recorded onto specially designed computer data sheets.

Eight hundred black and white prints and 1040 color slides were taken with a Nikon Nikkormat camera and 300 mm lens. The 55 mm lens was rarely used. Kodachrome 64 film was used for color slides, and one 15.2 m roll of 16 mm color movie film was taken.

Binoculars (7x35) were primarily utilized aboard shrimp boats and during land observations.

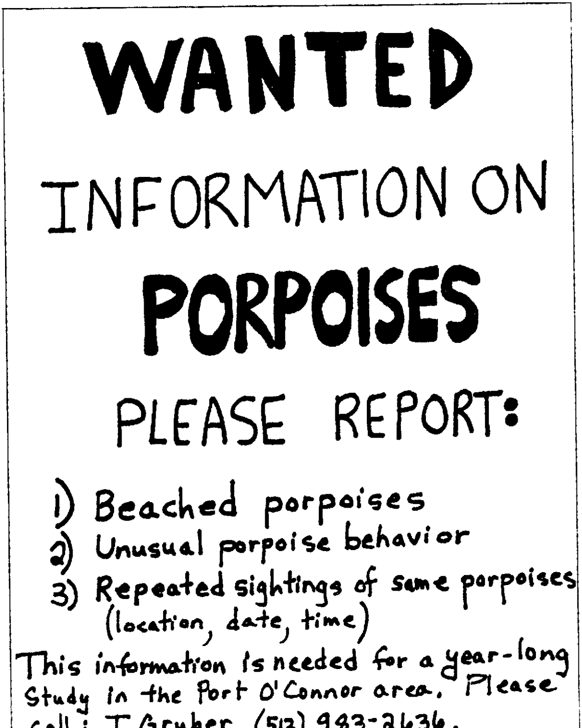


Fig. 5.— This notice was posted throughout Port O'Connor and surrounding towns to publicize the study and gain additional information about dolphins.

Data Sheets

Data in the field notes were recorded on computer sheets that were specifically developed for the three main observation types: regular, census, and shrimp boat.

Air and water temperatures were taken at the beginning of each day's session using a standard centigrade thermometer. Daily weather conditions were determined through the use of the National Oceanographic and Atmospheric Administration (NOAA) Coastal Weather Log, Coastal Station (NOAA Form 72-5a) and were: clear--zero to two-tenths of sky covered; partly cloudy--three-tenths to seven-tenths of sky covered; cloudy--eight-tenths to all of sky covered; storm near or present--imminent rain, rain, snow, or fog. The Petroleum Helicopter, Inc. (PHI) wind sock located opposite the project boat dock was used to obtain wind direction. Tidal conditions were determined by observing the flow of water around the pilings and channel markers in the Matagorda Ship Channel.

In addition to field notes, data sheets, stranding catalogues, and plotted maps of aerial and ground sightings, 64 "following" maps were drawn. When the travel routes and movements were plotted out on maps, movement patterns as well as the regular utilization of certain areas became more evident.

Data Analysis

Data analysis was conducted using the Amdahl V-6 computer at Texas A&M University. The Statistical Analysis System or SAS (SAS Institute, Inc., 1979) computational package was used for data analysis.

The General Linear Model, GLM (Ott, 1977) and Duncan's Multiple Range Test (Ott, 1977) were used to determine the significance of the relationships between dolphin abundance and section, dolphin abundance and month, and dolphin abundance and the interaction of section and month. The specific section locations of significant differences were then located. A Chi-Square Test (Ott, 1977) was used to test for the significance between direction of dolphin movement and tidal flow and time of day. The same test was also utilized to assess the relationship between certain behaviors and time of day, tidal flow, month and season. Relationships between mean group sizes, and month, season, time of day, depth, section, and behavior were determined through the use of the GLM procedure. The Duncan's Multiple Range Test identified those means which were significantly different. The Mann-Whitney U test (Ott, 1977) was also utilized to compare mean herd sizes in two sections of the study area.

Estimated dolphin density for each section was obtained by dividing the mean number of Tursiops/section surveyed, by the number of km^2 within that section. The quotient was then divided by the number of censuses conducted in the particular section during that month. The subsequent density estimate was then multiplied by the total number of km^2 in the section to obtain the mean number of dolphins per section per month. Entire study area totals by month were computed by summing the individual section monthly counts.

RESULTS

Spatial and Temporal Abundances

Estimates of dolphin abundance were calculated and plotted using the 315 censuses (250 census hours) conducted between 1 September 1978 and 31 August 1979. Throughout this section, the values following density estimates equal 1 SD about the mean.

Entire Study Area

Estimated dolphin density in the study area as a whole varied by month and season. The highest monthly estimate of dolphin density occurred during February with 1.29 ± 0.161 Tursiops/km^2 or 98.16 dolphins present in the study area (Fig. 6). Lowest monthly density occurred during April with an estimated 0.396 ± 0.094 Tursiops/km^2 or 30.08 dolphins.

Seasonal density conformed to the monthly results and ranged from an estimated winter high of 1.23 ± 0.071 Tursiops/km^2 to 0.640 ± 0.252 Tursiops/km^2 the following spring (Fig. 6). By multiplying the seasonal density values by the 75 km^2 total study site area, an estimated winter total of 93.39 ± 5.39 Tursiops and spring total of 48.60 ± 19.25 Tursiops were obtained.

Six Sections

Estimates of density and numbers were also computed on a yearly, monthly, and seasonal basis for each of the six sections of the study area (Table 3). The mean dolphin densities for the six sections over the entire year ranged from a high of 3.99 ± 2.17 Tursiops/km^2 (12.09 dolphins) in Section 3, to a low of 0.366 ± 0.284 Tursiops/km^2 (8.19 dolphins) in Section 5 (Fig. 7). Although Section 6 density was third lowest on a yearly basis (1.05 ± 0.639 Tursiops/km^2), the highest absolute number of dolphins present within a single section (17.38

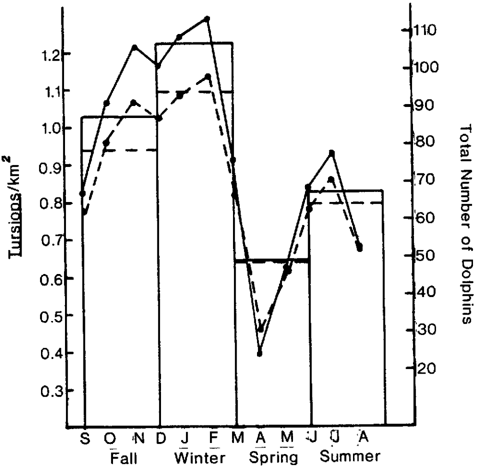


Fig. 6.— Estimated dolphin density (Tursiops/km^2) over the entire area by month and season. Histogram illustrates seasonal values. Broken lines of graph and histogram represent estimated number of dolphins over the entire study area by month and season.

TABLE 3.— Data on estimated dolphin density in each section by month, over the entire study area by month, and in each section over the entire year. (GLM factors follow.)

Section (km^2)	Month[a]	$\bar{X}$ Tursiops/km^2	Total No. Tursiops	SD	SE	Range Min	Range Max
1 (6.10)	Sept	0.615	3.75	0.70	0.25	0.000	2.130
2 (20.42)		0.362	7.39	0.29	0.13	0.042	0.722
3 (3.02)		0.662	2.00	-	-	0.662	0.662
4 (7.46)		2.280	17.00	1.00	0.41	0.536	3.220
5 (22.4)		0.702	15.72	0.42	0.16	0.130	1.300
5 (16.53)		1.050	17.29	0.80	0.30	0.302	2.600
Total[b]		0.832	63.15	0.09	0.04	0.000	3.220
1	Oct	2.100	12.80	1.32	0.42	0.000	4.430
2		0.188	3.84	0.19	0.08	0.000	0.425
3		8.590	25.94	4.01	2.32	9.270	16.223
4		2.550	19.00	1.50	0.47	0.000	5.360
5		0.186	4.17	0.20	0.09	0.000	0.486
6		0.931	15.40	0.57	0.25	0.363	1.690
Total		1.060	80.65	0.11	0.04	0.000	16.230
1	Nov	2.620	16.00	1.23	0.55	1.150	4.430
2		0.470	9.60	0.30	0.14	0.850	0.510
3		5.830	17.60	5.41	2.42	0.000	12.580
4		3.070	22.88	1.01	0.36	1.610	4.960
5		0.232	5.20	0.29	0.13	0.000	0.681
6		1.230	20.33	0.44	0.25	0.726	1.510
Total		1.210	91.61	0.09	0.04	0.000	12.580
1	Dec	2.020	12.33	0.53	0.30	1.640	2.620
2		0.833	17.00	0.20	0.10	0.512	0.977
3		4.130	12.47	0.23	0.17	5.960	6.290
4		1.900	14.20	0.48	0.21	1.070	2.280
5		0.313	7.01	0.17	0.10	0.097	0.422
6		1.530	25.83	0.70	0.40	0.726	1.990
Total		1.170	88.84	0.08	0.04	0.000	6.290
1	Jan	2.950	18.00	2.32	1.64	1.310	4.590
2		0.906	18.50	0.57	0.29	0.340	1.570
3		3.150	9.50	0.23	0.17	2.980	3.310
4		3.020	22.50	0.47	0.34	2.680	3.350
5		0.000	0.00	0.00	0.00	0.000	0.000
6		1.550	25.67	0.77	0.44	0.968	2.420
Total		1.240	94.17	0.12	0.05	0.000	4.590
1	Feb	1.940	12.00	0.70	0.49	1.480	2.460
2		0.600	12.25	0.26	0.13	0.340	0.892
3		3.150	9.50	1.64	1.16	1.990	4.300
4		2.140	16.00	1.28	0.64	1.340	4.020
5		0.342	7.66	0.21	0.12	0.097	0.486
6		2.470	40.75	1.37	0.68	1.210	3.930
Total		1.290	98.16	0.16	0.07	0.0 0	4.300

TABLE 3 (Continued).

Section (km²)	Month	$\bar{X}$ Tursiops/km²	Total No. Tursiops	SD	SE	Range Min	Range Max
1 (6.10)	Mar	1.910	11.67	1.12	0.46	0.328	3.440
2 (20.42)		0.551	11.25	0.36	0.18	0.170	0.977
3 (3.02)		3.970	12.00	3.75	2.65	1.320	6.620
4 (7.46)		0.345	2.57	0.49	0.18	0.000	1.340
5 (22.4)		0.313	7.01	0.14	0.10	0.130	0.324
6 (16.53		1.450	24.00	0.78	0.30	0.544	2.540
Total		0.902	68.50	0.09	-	0.000	6.620
1	Apr	0.205	1.25	0.31	0.16	0.000	0.656
2		0.849	17.33	0.24	0.14	0.467	0.935
3		0.497	1.50	0.70	0.50	0.000	0.993
4		0.000	0.00	0.00	0.00	0.000	0.000
5		0.000	0.00	0.00	0.00	0.000	0.000
6		0.605	10.00	0.68	0.39	0.181	1.390
Total		0.396	30.08	0.09	0.04	0.000	1.390
1	May	1.580	9.63	1.33	0.47	0.000	3.440
2		0.607	12.39	0.46	0.21	0.000	1.060
3		4.420	13.33	3.18	1.84	0.993	7.280
4		0.201	1.50	0.40	0.20	0.000	0.804
5		0.238	5.33	0.22	0.13	0.000	0.421
6		0.305	5.00	0.37	0.15	0.000	0.907
Total		0.621	47.18	0.06	0.03	0.000	7.280
1	June	1.890	11.50	0.62	0.62	0.164	3.110
2		0.744	15.19	0.15	0.15	0.340	1.100
3		5.500	16.60	1.59	1.59	2.650	11.590
4		0.000	0.00	0.00	0.00	0.000	0.000
5		0.536	12.00	0.16	0.16	0.000	0.778
6		0.484	8.00	0.19	0.19	0.000	1.090
Total		0.834	63.29	0.04	0.04	0.000	11.590
1	July	2.500	15.25	0.81	0.81	0.328	4.100
2		0.784	16.00	0.26	0.26	0.085	1.320
3		4.300	13.00	1.32	1.32	2.980	5.630
4		0.536	4.00	0.54	0.54	0.000	1.610
5		0.476	10.66	0.14	0.14	0.162	0.616
6		0.726	12.00	0.18	0.18	0.181	1.390
Total		0.934	70.91	0.02	0.02	0.000	5.630
1	Aug	1.360	8.29	1.05	1.05	0.000	7.380
2		0.212	4.33	0.09	0.09	0.000	0.595
3		3.860	11.67	0.40	0.40	3.310	4.640
4		0.000	0.00	0.00	0.00	0.000	0.000
5		1.050	23.52	0.10	0.10	0.162	1.130
6		0.262	4.33	0.79	0.79	0.000	0.544
Total		0.687	52.14	0.04	0.04	0.000	7.380

TABLE 3 (Continued).

Section[c]	$\bar{X}$ Tursiops/km^2	Total No. Tursiops	SD	SE
1	1.800	11.00	1.51	0.190
2	0.592	12.09	0.37	0.050
3	3.990	12.05	3.86	0.682
4	1.340	9.97	1.47	0.190
5	0.366	8.19	0.35	0.050
6	1.050	17.38	0.85	0.110

GLM:Model Density = Section Month Section*Month[d]

Source	d.f.	Type I SS	F Value	PF > F	Error	Corrected Total
Section	5	522.36	60.13	0.0001	d.f.: 243	d.f.: 314
Month	11	83.70	4.38	0.0001	SS: 422.17	SS: 1306.17
Section*Month	55	277.94	2.91	0.0001		

[a]Estimated dolphin density in each section by month.

[b]Estimated dolphin density over the entire study area by month.

[c]Estimated dolphin density in each section over the entire year.

[d]GLM factors.

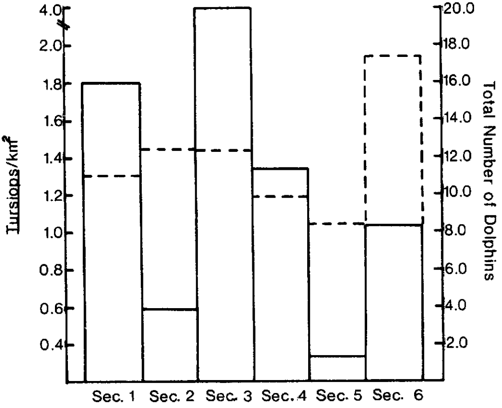


Fig. 7.— Estimated dolphin density (Tursiops/km^2) over the entire year by section. Broken lines represent estimated number of dolphins over the entire year by section.

Tursiops) occurred there.

Sections by Month

Peaks in abundance occurred during different months in the different sections. Monthly density ranged from a high of 8.59 ± 4.01 Tursiops/km^2 (25.44 dolphins) in Section 3 in October, to a low of 0.0 ± 0.0 Tursiops/km^2 in Section 4 during April, June, and August, and in Section 5 during January and April (Figs. 8 and 9). Although estimates for the entire study area peaked in February, those for Sections 1 and 2 were highest in January, and for Sections 3 and 4 were highest in October and November, respectively. Section 5 counts were highest during August, and Section 6 peaked during February. Lows for Sections 1, 3, and 4 occurred during April. Densities in Section 2 were lowest during October, and in Section 6 during August.

Section, month, and the interaction between section and month were highly significant ($p < 0.0001$) factors influencing population density and explaining abundance variability within the study area. No significant differences at the 0.05 level were found between Sections 1 and 4 or Sections 2 and 5. However, significant differences were found between Section 3 and all other sections, between both Sections 1 and 4 and the remainder of the study area, between Section 6 and the remaining sections, and between both Sections 2 and 5 and the remainder of the study area.

Sections by Season

Estimated seasonal density (Fig. 10) ranged from a high of 5.03 ± 4.02 Tursiops/km^2 (15.18 dolphins) in Section 3 during the fall, to a low of 0.179 ± 0.309 Tursiops/km^2 (1.34 dolphins) in Section 4 during the summer. Sections 3 and 4 exhibited highest estimated density during the fall, and Sections 1, 2, and 6 dolphin densities peaked during the winter. Section 5 exhibited greatest dolphin density and numbers during the summer.

Examination of the three highest density estimates among the six

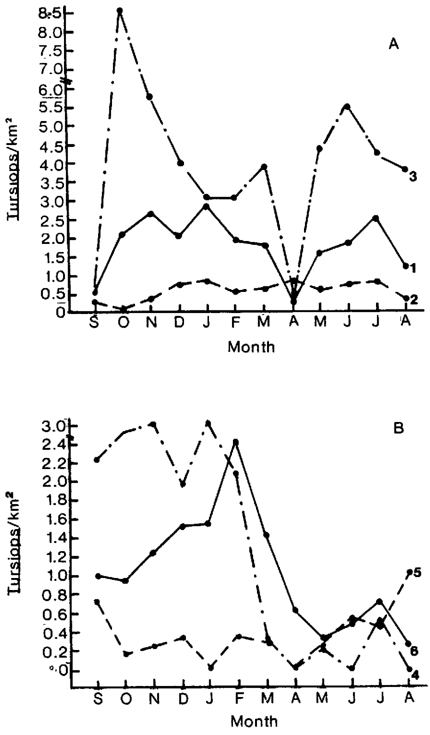


Fig. 8.— Estimated dolphin density (Tursiops/km^2)/section by month in (A) Sections I-III, and (B) Sections IV-VI.

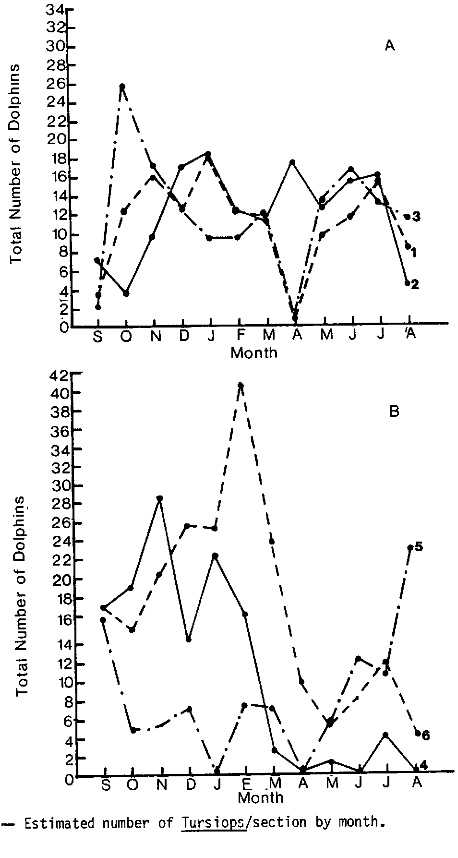


Fig. 9.— Estimated number of Tursiops/section by month.

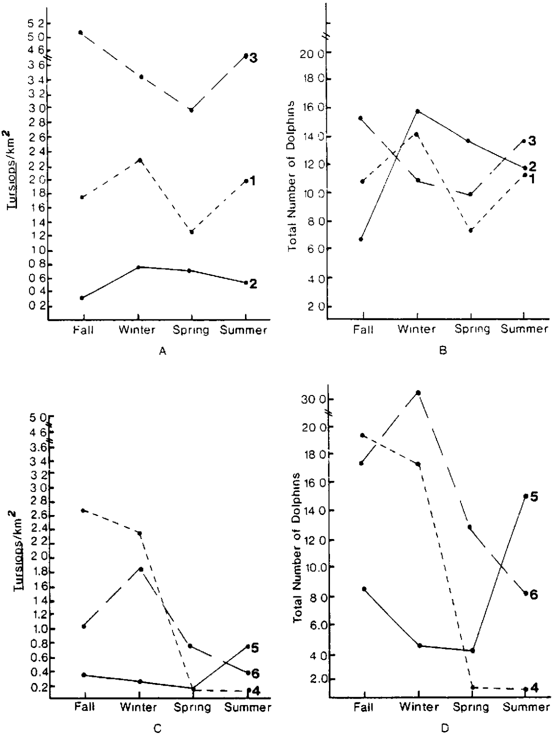


Fig. 10.— (A and C) Estimated dolphin density (Tursiops/km^2)/section by season. (B and D) Estimated number of dolphins/section by season.

sections by season suggests that dolphins concentrated in Sections 3, 4, and 1 during the fall and winter. Fall estimates of 5.03 ± 4.02 Tursiops/km^2, 2.63 ± 0.394 Tursiops/km^2, and 1.78 ± 1.04 Tursiops/km^2 and winter densities of 3.47 ± 0.506, 2.36 ± 0.592, and 2.31 ± 0.552, respectively, were observed there. Spring concentrations were greatest in Sections 3, 1, and 6 (2.96 ± 2.15, 1.23 ± 0.906, and 0.786 ± 0.483 Tursiops/km^2, respectively); the highest summer densities (4.55 ± 0.849, 1.91 ± 0.570, and 0.687 ± 0.308 Tursiops/km^2) were noted in Sections 3, 1, and 5, respectively.

The portion of Section 2 along the Matagorda Peninsula is physiographically similar to Section 4. However, they exhibited extremely different density estimates by season. Estimated fall and winter densities for Section 2 were 0.340 ± 0.141 Tursiops/km^2 and 0.780 ± 0.071 Tursiops/km^2 in contrast to densities of 2.63 ± 0.394 and 2.36 ± 0.592 Tursiops/km^2 in Section 4. Spring and summer densities within both sections remained virtually unchanged (0.669 ± 0.136 and 0.580 ± 0.316 Tursiops/km^2, Section 2; 0.182 ± 0.173 and 0.179 ± 0.309 Tursiops/km^2, Section 4).

Aerial Observations

Aerial observations offered insight into dolphin numbers and concentrations, and seasonal movement patterns and distribution. They also acted as rough verification for boat censuses, provided additional behavioral observations, and offered an alternate observation platform during periods of low tides when portions of the study area were inaccessible by boat. Although circumstances forced the reduction of flights both in number and scope, they proved efficacious in these terms.

The majority of the study area was covered during the September and October 1978 flights, but only small portions of the marshland channels, Pass Cavallo, and the Matagorda Ship Channel were surveyed in the winter and early spring flights. Even so, the distribution of Tursiops (Figs. 11-13) appears somewhat representative of the distribution determined from boat censuses conducted throughout the year.

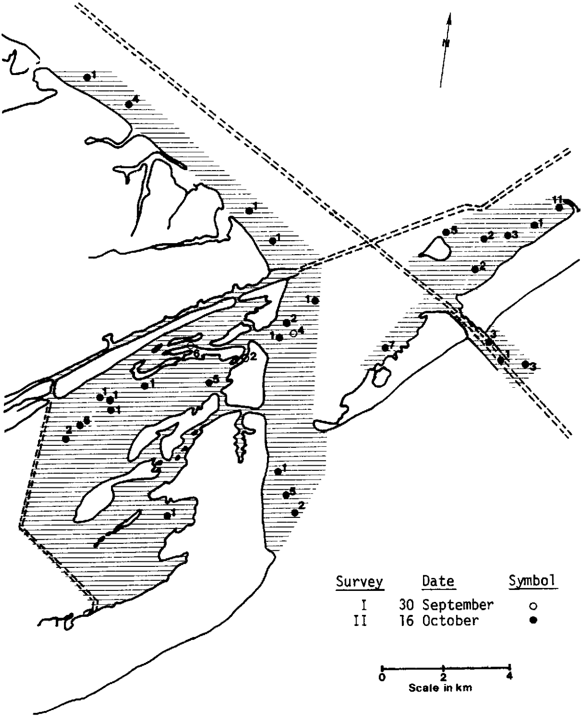


Fig. 11.— Aerial surveys I and II (speed: 145 km/hr; altitude: 152 m) conducted in September and October 1978. Shaded portions represent regions surveyed. The number beside each survey date's symbol represents the number of dolphins counted at that location.

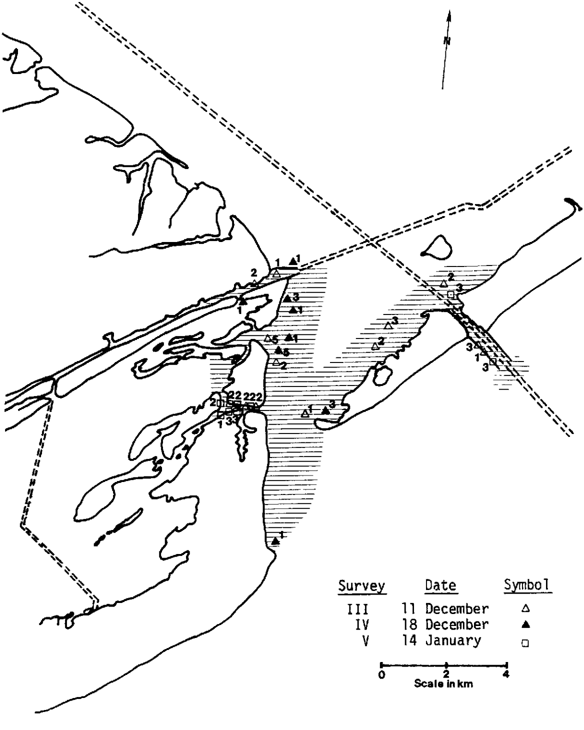


Fig. 12.— Aerial surveys III, IV, and V (speed: 145 km/hr; altitude: 152 m) conducted in December 1978 and January 1979. Shaded portions represent regions surveyed. The number beside each survey date's symbol represents the number of dolphins counted at that location.

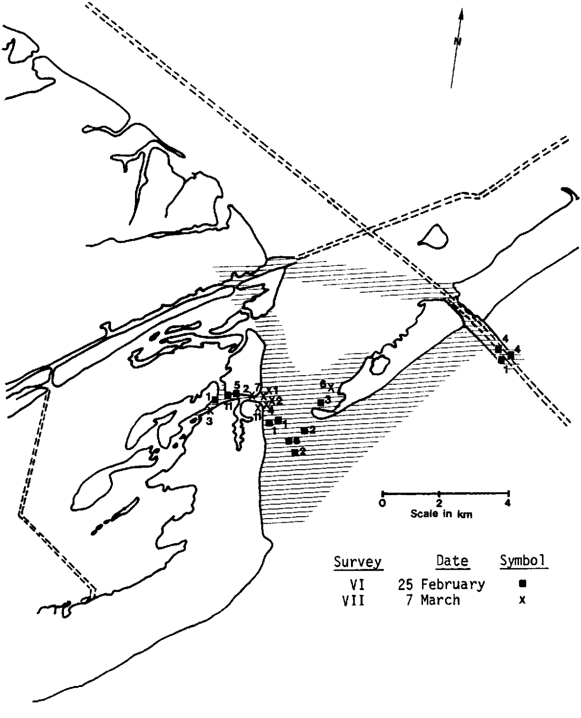


Fig. 13.— Aerial surveys VI and VII (speed: 145 km/hr; altitude: 152 m) conducted in February and March 1979. Shaded portions represent regions surveyed. The number beside each survey date's symbol represents the number of dolphins counted at that location.

Concentrations of bottlenosed dolphins were generally present both in and around the mouths of the Port O'Connor jetties, Big Bayou, and Saluria Bayou, as well as in Pass Cavallo (especially near Decros Point and the tip of Matagorda Island), the Matagorda Ship Channel jetties, and along the Matagorda Peninsula shoreline.

Figures 11-13 may also be compared to Barham et al.'s (1980) dolphin sightings during March and April 1978 (Fig. 14), as well as to the National Marine Fisheries Service (NMFS) aerial surveys, which were undertaken in May, August, and November 1980 and February 1981 (Figs. 15-18). Again, peak areas included the mouth of the Port O'Connor jetties, in and around the mouth of Saluria Bayou, in Pass Cavallo particularly off Matagorda Island and Matagorda Peninsula (Decros Point), and in and around the Matagorda Ship Channel jetties. Especially evident in the November NMFS aerial survey was the sharp increase over August of dolphins in the marshlands and in the vicinity of Pass Cavallo. Weather and sea state conditions were very good and quite comparable both times. The increased number of sightings in that area may have indicated a seasonal change in distribution, possibly corroborating this investigator's observations of an increase of Tursiops in Sections 1 and 6 beginning in October and November, respectively, and peaking in January and February 1979. During the February 1981 NMFS aerial surveys, the highest numbers of dolphins in the Pass Cavallo area were concentrated in Pass Cavallo off the tip of Matagorda Island, and in and around the Matagorda Ship Channel jetties.

Estimated density in the Pass Cavallo area during this study (0.93 ± 0.252 Tursiops/km^2) appears comparable to, and in some cases slightly higher than, other inshore regions which have been surveyed (Table 4). Other density estimates which range from lows of 0.06 and 0.12 Tursiops/km^2 offshore of the Florida Peninsula and Panhandle (Gulf of Mexico shoreline) to a high of 2.63 Tursiops/km^2 in the Aransas Pass, Texas, area, suggest highest concentrations of dolphins in deep channels, passes, and salt river areas.

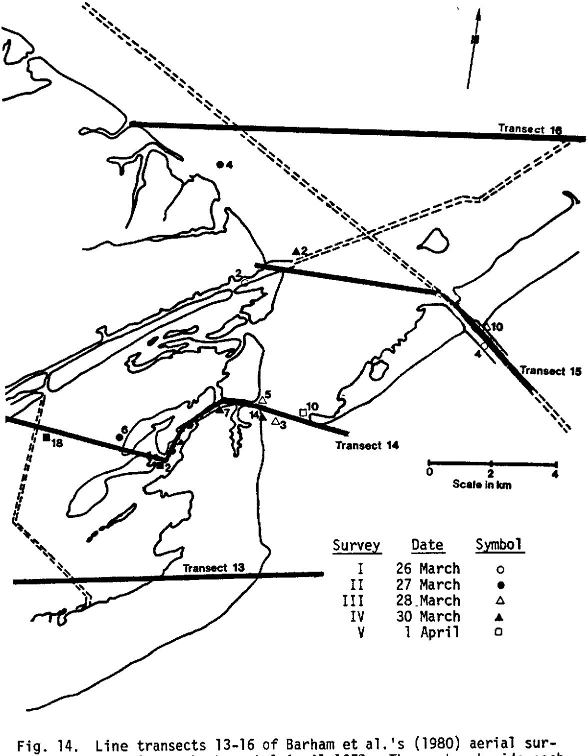


Fig. 14. Line transects 13-16 of Barham et al.'s (1980) aerial surveys conducted 26 March through 1 April 1978. The number beside each survey date's symbol represents the number of dolphins counted at that location.

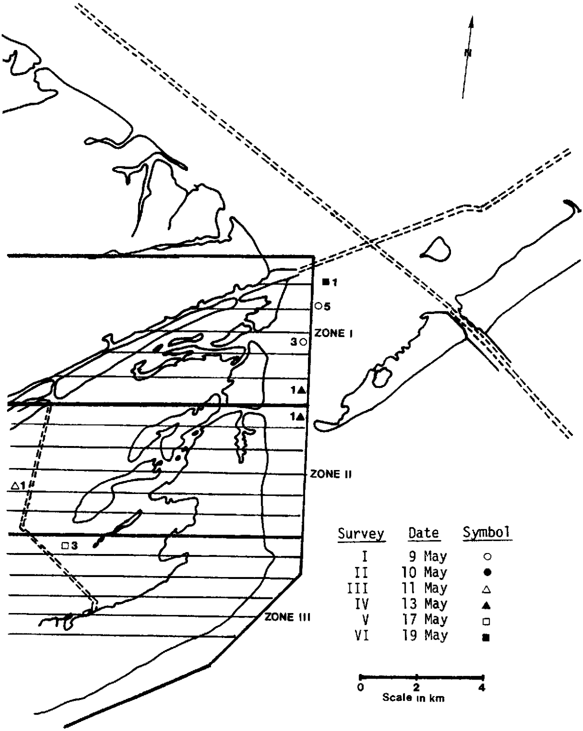


Fig. 15.— Zones I - III of the National Marine Fisheries Service (NMFS) aerial surveys (speed: 145 km/hr; altitude: 225 m) conducted 6-17 May 1980. (Six replicates; 1 transect/zone/day.) The number beside each survey date's symbol represents the number of dolphins counted at that location.

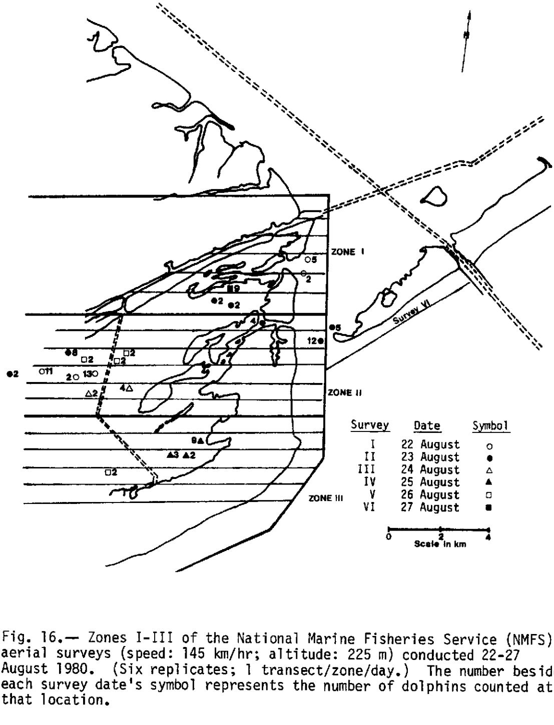
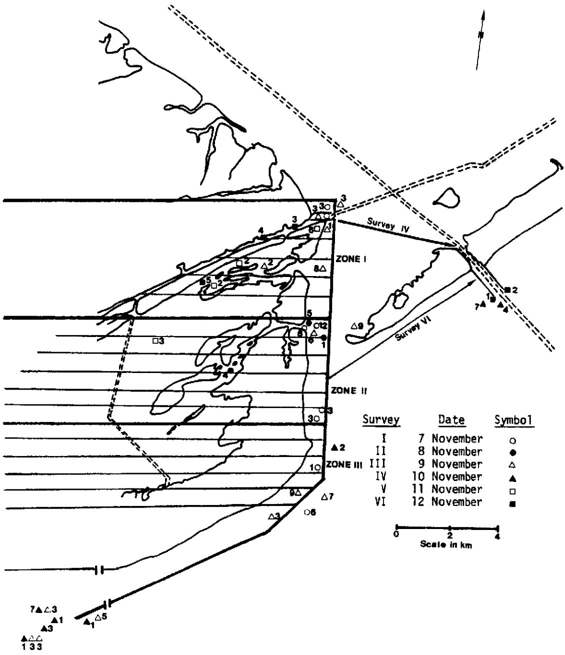


Fig. 16.— Zones I-III of the National Marine Fisheries Service (NMFS) aerial surveys (speed: 145 km/hr; altitude: 225 m) conducted 22-27 August 1980. (Six replicates; 1 transect/zone/day.) The number beside each survey date's symbol represents the number of dolphins counted at that location.



Survey	Date	Symbol
I	7 November	○
II	8 November	●
III	9 November	△
IV	10 November	▲
V	11 November	□
VI	12 November	■

Fig. 17.— Zones I-III of the National Marine Fisheries Service (NMFS) aerial surveys (speed: 145 km/hr; altitude: 225 m) conducted 7-12 November 1980. (Six replicates; 1 transect/zone/day.) The number beside each survey date's symbol represents the number of dolphins counted at that location.

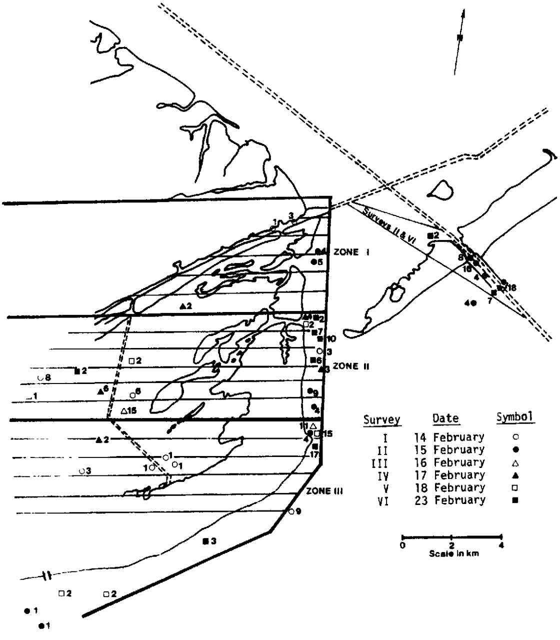


Fig. 18.— Zones I-III of the National Marine Fisheries Service (NMFS) aerial surveys (speed: 145 km/hr; altitude: 225 m) conducted 17-23 February 1981. (Six replicates; 1 transect/zone/day.) The number beside each survey date's symbol represents the number of dolphins counted at that location.

TABLE 4.— Density estimates for *Tursiops* in selected areas of the Gulf of Mexico and the Indian and Banana Rivers in Florida.

Location	*Tursiops*/km^2	Reference
Louisiana Gulf Coast	0.44	Leatherwood et al. (1978a) (A)*
Mississippi Gulf Coast	0.23	Leatherwood et al. (1978a) (A)
Texas Gulf Coast		
Including Aransas Pass Area	0.75	Barham et al. (1980) (A)
Excluding Aransas Pass Area	0.62	Barham et al. (1980) (A)
Aransas Pass Area	2.63	Barham et al. (1980) (A)
Pass Cavallo Area	0.93	This Study (B)**
Florida Gulf Coast		
Inshore, Sarasota Area	1.20	Irvine et al. (1979) (B)
Northern Half of Study Area	1.80	Irvine et al. (1979) (B)
Southern Half of Study Area	0.60	Irvine et al. (1979) (B)
Offshore		
Peninsula	0.06	Odell and Reynolds (1980) (A)
Panhandle	0.12	Odell and Reynolds (1980) (A)
Florida Indian and Banana Rivers	0.68	Leatherwood, (1979) (A)

* (A) - Aerial
** (B) - Boat

"Naturally Tagged" Dolphins

In order to undertake an in-depth study of the movements, social composition, and behavior of bottlenosed dolphins, it was essential that several individuals be recognizable over an extended period of time, from one encounter to the next. The 20 dolphins from throughout the study area which were most identifiable by unique markings, scars, and discolorations, or uniquely torn or nicked dorsal fins, were designated "natural tags". Table 5 presents the name of each animal, initial sighting date and location, and total number of times sighted during 1978-1979. Photographs of several of the "natural tags" may be found in Fig. 19.

Home Range

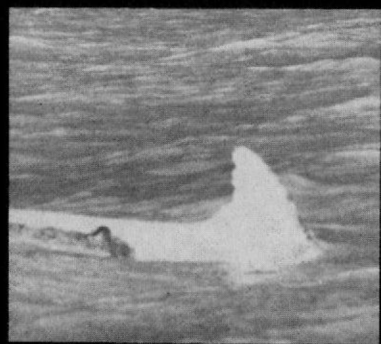
The concept of "home range", the area an individual regularly covers during the course of its normal activities (Burt, 1943; Jewell, 1966) has been applied to the movements and activity patterns of Tursiops by several authors (Caldwell, 1955; Saayman et al., 1972, 1973; Shane, 1977; Shane and Schmidly, 1978; Irvine et al., 1979; Wells et al., 1980). Several "naturally tagged" dolphins were regularly observed in the same portions of the study area throughout the year or on a seasonal basis, thereby supporting the argument for the existence of individual home ranges. Those dolphins rarely sighted were invariably recorded in the same regions during each encounter.

Many of the "natural tags" were seen too infrequently to accurately pinpoint the entirety of their movements. The sporadic nature of many of the sightings may have indicated home ranges that extended far out of the study area or the regular use of one or more additional home ranges. The fact that dolphins seen even a few times during the year were recorded in the same regions suggests that certain areas were preferred over others, and that movement and distribution, within the study area at least, were of a localized nature.

The term "home range", as it is used in this thesis, refers to the section of the dolphin's entire range which fell within the chosen

TABLE 5.— Name of each "naturally tagged" Tursiops, initial sighting date and location, and total number of times sighted.

Name	Sighting Date	Location	Times Sighted
Sea Wolf	7-13-78	Matagorda Ship Channel off Powderhorn Ranch (Grid 27)	3
Kinara	7-15-78	Matagorda Peninsula shoreline NE Section 2 oil wells (Grid 25)	34
Kalypso	7-26-78	Saluria Bayou (U.S.C.G. ruins) (Grid 82)	24
Gash	9-4-78	Mouth of Port O'Connor jetties (Grid 63)	10
Ourania	9-11-78	Indianola Harbor/Powderhorn Lake (Grid 41)	7
Flag	10-28-78	Ends of Matagorda Ship Channel jetties (Grid 32)	2
Kalymnos	10-29-78	Ends of Matagorda Ship Channel jetties (Grid 32)	1
Pointed Finger	11-5-78	SE of Port O'Connor jetties (Grid 15)	19
Little Chopped	11-9-78	2.5 km NW Peninsula Bulkhead (Grid 93)	9
Ilios	11-26-78	Peninsula bulkhead (Grid 37)	5
Aliki	12-4-78	Intracoastal Waterway between Port O'Connor jetties and Fisherman's Cut (Grid 64)	18
Antimos	2-12-79	Intracoastal Waterway/Fisherman's Cut (Grid 65)	6
Ragamuffin	3-1-79	Saluria Bayou/Mitchell's Cut (Grid 83)	7
Tal	3-9-79	SE Port O'Connor jetties (Grid 15)	8
Stubby	3-20-79	Between Bayucos Island and Grass Island (Grid 86)	4
Gil	3-20-79	Saluria Bayou/Mitchell's Cut (Grid 83)	7
Huckleberry	5-6-79	Big Bayou (Grid 76)	5
Echo	6-13-79	Shallows NW Port O'Connor jetties (Grid 57)	2-3
Thick Fin	6-29-79	Gulf of Mexico; 50 m SE Matagorda Ship Channel jetties	1
Xenon	7-12-79	75 m NE Indianola Harbor (Grid 44)	1



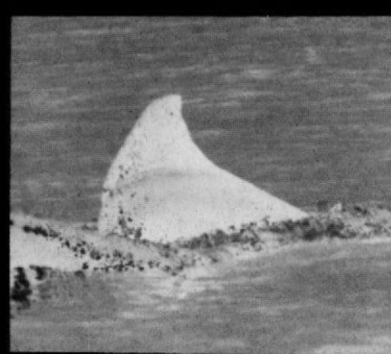
Kalypso

Ourania

Pointed Finger

Aliki

Ilios



Thick Fin

Fig. 19.—Photographs of the fins of six "natural tags".

boundaries of the study site. Individual home range maps of each "natural tag" will be presented under the section entitled "'Natural Tag' Individual Home Ranges".

Social Differentiation

In order to understand study area utilization as it relates to the dolphins' social structure and home range, the terms "pod", "herd", and "extended herd" must be clarified. A "pod" contains anywhere from a single individual to eight or nine dolphins actively associating with one another at any given time, and generally performing the same behavior in close proximity or less than 1 to 2 m apart. Several pods of varying sizes, each of which may or may not be actively associating with another pod or engaged in the same behavior, but that together form a fairly cohesive unit within an area of 100 to 200 m at any given time, constitute a "herd". An exception to this occurred in the case of "porpoise parades", in which small pods strung themselves out in a long, narrow line which extended 1.0 to 1.5 km. Such pods, evenly spaced from one another and engaged in steady, forward travel, constituted a single herd. During this study, herds numbered anywhere from eight or nine to approximately 40 dolphins.

The term "extended herd" characterizes membership of particular individuals in a large, socially interacting unit. The "extended herd" denotes long-term membership in the social unit in contrast to the "herd" which indicates the presence of many individuals within a limited area because of attractive environmental factors coupled with social bonds known to exist at that moment in time only. Animals within the same extended herd need not be located within the same, limited area at any given time. An animal sighted alongside or with a pod of dolphins may be a member of an extended herd that is scattered over a distance of many kilometers in several seemingly unrelated pods. Upon other occasions, extended herd members may be seen feeding or traveling together.

Extended Herd Home Ranges

Most "naturally tagged" dolphins were found in the same general regions from one encounter to the next. With one exception, "natural tags" regularly sighted in one area were never observed associating with "natural tags" from another region. It appeared that the majority of "naturally tagged" Tursiops belonged to one of three inshore extended herds, each with its own home range which overlapped with the study area. In order to simplify, the term "extended herd home range" will be written as "herd range" throughout the remainder of the text. Herd Range I (Fig. 20) included Pass Cavallo, an adjacent portion of Matagorda Bay to the north and northeast, and the marshland channels, flats, and embayments to the southwest, i.e., Sections 1, 2 and 6. Nearly all sightings of Kinara, Kalypso, Gash, Pointed Finger, Aliki, Antimos, Ragamuffin, Tal, Stubby, Gil, Huckleberry, and Echo were recorded in Herd Range I. Herd Range II (Fig. 20) extended from several hundred meters southwest of the Matagorda Ship Channel (Grids 19, 20, 25, and 26), northeast along Matagorda Peninsula to the bulkhead (Section 4), north towards the middle of Matagorda Bay, and northwest to the Matagorda Ship Channel and Intracoastal Waterway. Ilios and Little Chopped were always observed in these areas. Herd Range III (Fig. 20) included the northwestern two-thirds of Section 5, an unknown portion of Powderhorn Lake, and an undetermined distance farther northwest and north in Matagorda Bay. Sea Wolf, Ourania, and Xenon were recorded in this area. Flag and Kalymnos, two of the three dolphins that did not appear to have home ranges within Matagorda Bay, were sighted twice at the ends of the Matagorda Ship Channel jetties (Grid 32). They were representative of an apparently separate population of Tursiops that frequented the near-shore Gulf of Mexico. Most of these dolphins had uniquely ripped dorsal fins that were often infested with the obligate cetacean barnacle Xenobalanus globicipitus. Although such dolphins were rarely noted in Matagorda Bay, movement within and just outside the Ship Channel jetties was observed upon several occasions. One uniquely marked dolphin that was photographed inside the jetties on 8 March 1979 was fortuitously sighted a second time 20 months later

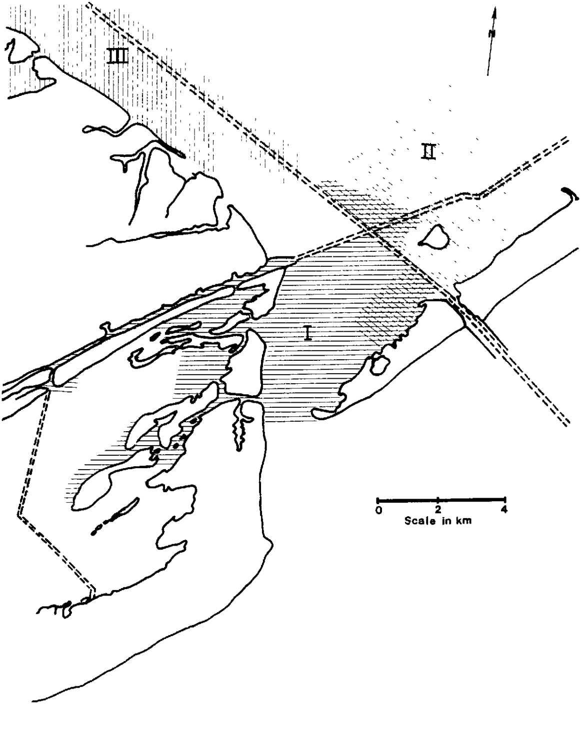


Fig. 20.— Inshore extended Herd Ranges I, II, and III which overlapped with the study area.

as it milled around the ends of the jetties on 6 November 1980. The two sightings within 0.5 km of one another may indicate that the use of home ranges, or, at least, certain preferred areas, may be characteristic of "Gulf" dolphins as well as those which appear to frequent inshore waters.

A third "naturally tagged" dolphin, observed in the Gulf 0.5 km southwest of the Matagorda Ship Channel jetties, was recognized and confirmed as Thick Fin, a previously identified animal from an earlier study in the Aransas Pass area of Texas, 95 km to the southwest (Shane, 1977; Shane and Schmidly, 1978).

Herd ranges were assumed to extend an unknown distance beyond the study area. Chance sightings of several "natural tags" suggested that Herd Range I probably extended farther southwest in Espiritu Santo Bay. The northeastern limit of Herd Range I appeared to be the Matagorda Ship Channel, since only three out of 144 sightings of Herd Range I dolphins were recorded northeast of it in Herd Range II. No Herd Range I dolphins were ever sighted farther northwest than the Port O'Connor jetties and the Intracoastal Waterway. Some degree of overlap between the northeastern extent of Herd Range I, and the southwestern limit of Herd Range II occurred in Grids 18 to 20 and 24 to 26. It is not known to what extent Herd Range II extended to the north and northeast in Matagorda Bay, although sightings of Little Chopped in both of those areas contributed insight into the potential expanse of Herd Range II. Herd Range III also appeared to extend farther north and northwest in Matagorda Bay and into Powderhorn Lake. No Herd Range I or Herd Range II "natural tags" were ever sighted in Herd Range III, and Herd Range III dolphins were never noted south of Broad Bayou (adjacent to Grid 48 in Section 5). The frequent sightings of previously unrecorded, indentifiable dolphins in the northwestern half of Section 5 also led to the strong impression that Herd Range III extended far to the northwest and north of Section 5.

"Natural Tag" Individual Home Ranges

The "natural tags'" individual home range sizes, sighting occurrence, location, and seasonal fluctuation in location varied. "Naturally tagged" dolphin sightings by month and season are presented in Table 6, and Figures 21-24 plot all locations in which each dolphin was found.

Sea Wolf (Fig. 21) was sighted only three times during the study, but was always seen in the same location. On 26 June 1979, Sea Wolf was sighted traveling to the northwest near another "natural tag", Ourania (Fig. 21), who was also always found in Herd Range III. Ourania was sighted a total of seven times, in September, October, and November 1978 and February, March, and June 1979. Initially noted moving in and out of Powderhorn Lake on 11 September 1978, she and her calf then continued northwest along the Matagorda Bay shoreline. Successive sightings predominated near the northwestern periphery of the study area with the exception of a June 1979 sighting when she was observed farther south than usual while following a shrimp boat towing to the south in the Matagorda Ship Channel. Known to frequent Powderhorn Lake and regions northwest of the study area, the relatively few sightings of Ourania were probably due to her more frequent utilization of those areas.

A third dolphin, Xenon (Fig. 21), was noted a single time along the extreme northwestern boundary of the study area. An extremely large Tursiops, Xenon was infected with the skin fungus Lobomycosis, and the dorsal surface from the trailing edge of the fin to the anterior portion of the tail flukes appeared as a scarred, wart-like, thick, crusty, pinkish-white surface. It is unlikely that only a single sighting of such a distinctively marked individual would occur unless its presence in the area were extremely limited. Xenon's southeasternmost home range limit appeared to overlap with the northwesternmost limit of the study area.

Kinara (Fig. 21) was sighted a total of 34 times during the year, and was one of several dolphins whose home range included study area Sections 1, 2, and 6 (Herd Range I). A chance sighting of Kinara and Stubby southwest of the study area expanded this dolphin's known range into the northeastern portion of Espiritu Santo Bay. Kinara was originally sighted in Section 2 near Matagorda Peninsula during

TABLE 6.— Number of times each "naturally tagged" dolphin was sighted during the summer of 1978 pilot study and during each month and season of the year-long study.

	Summer 1978	S	O	N	D	J	F	M	A	M	J	J	A	Summer 1978	F	W	S	SU	Total No. of Times Sighted
Sea Wolf	1		1								1			1	1	0	0	1	3
Kinara	1		1	3	1	2	4	7	6	5	1		3	1	4	7	18	4	34
Kalypso	1	3			1	1	1	7	5	1	1	3		1	3	3	13	4	24
Gash		3	1					4	1		1				4	0	5	1	10
Ourania		1	1	1			1	1			2				3	1	1	2	7
Flag			2												2	0	0	0	2
Kalymnos			1												1	0	0	0	1
Pointed Finger				3	3	2	1	4		2	1	3			3	6	6	4	19
Little Chopped				1	2	3	1		1				1		1	6	1	1	9
Ilios				1	1	1	1				1				1	3	0	1	5
Aliki					2	1	3	6	2		3	1			0	6	8	4	18
Antimos							2	1			3				0	2	1	3	6
Ragamuffin								1		1	1	3	1		0	0	2	5	7
Tal								2	3	1			2		0	0	6	2	8
Stubby								1	1		1		1		0	0	2	2	4
Gil								3	3	1					0	0	7	0	7
Huckleberry										1	3	1			0	0	1	4	5
Echo			1?									1	1		0?	0	0	2	2-3?
Thick Fin											1				0	0	0	1	1
Xenon												1			0	0	0	1	1

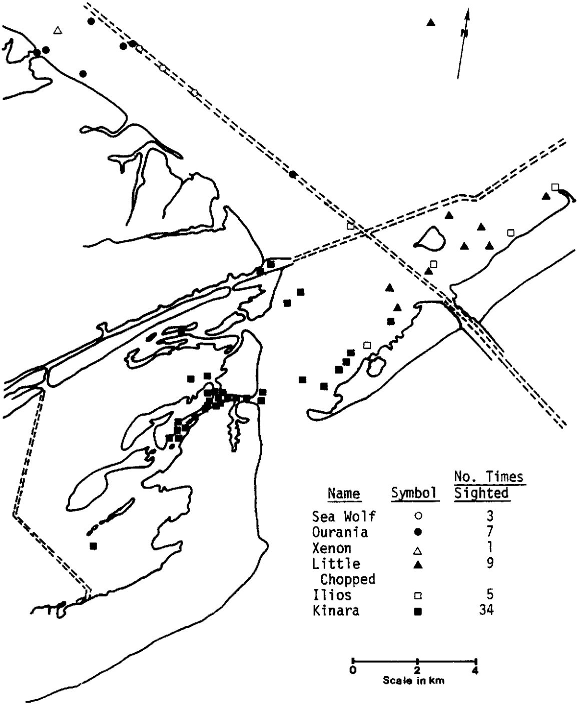


Fig. 21.— Home ranges of several of the "natural tags" which overlapped with the study area.

the summer of 1978, and subsequent sightings during the fall and winter were primarily recorded in Saluria Bayou and its environs to the northeast (Pass Cavallo) and to the southwest (Devil's Elbow). Kinara and many other Tursiops were found in those areas from late fall until March when increased movement into Section 2 was noted. Subsequent observations of Kinara in the spring and summer were most common in Matagorda Bay along the southwestern portion of the Peninsula where this dolphin had been initially sighted during the previous summer.

Kalypso (Fig. 22), observed 24 times, was usually recorded in or near Saluria Bayou and in the Intracoastal Waterway of Section 6. Observations of this dolphin traveling southwest into Espiritu Santo Bay during March and April 1979 expanded the originally proposed home range. Kalypso was seen only in Saluria Bayou during September, and only in the Intracoastal Waterway near Fisherman's Cut during December, January, and February. March, April, and May sightings predominated in or near Saluria Bayou. During June, and twice in July, Kalypso was observed in Matagorda Bay and near the Port O'Connor jetties.

Pointed Finger (Fig. 22), observed 19 times, was nearly always found in Herd Range I but was also sighted traveling in the far outlying regions of that range as well as outside of it. The first four sightings of Pointed Finger in November and December 1978 were all recorded off the Port O'Connor jetties. The fifth observation, also in December, was recorded 2.8 km from the jetties in the Matagorda Ship Channel, several hundred meters north of Herd Range I. Then, in January, Pointed Finger was followed over 5 km from the Port O'Connor jetties into Section 4. On 23 February 1979, this dolphin was sighted at the intersection of the Intracoastal Waterway and the Army Cut, 14 km from its previous sighting. Depending upon Pointed Finger's route of travel, its home range may have thus included a portion of Espiritu Santo Bay. March sightings of Pointed Finger were all recorded in the Saluria Bayou-Devil's Elbow area, and summer sightings alternated between the marshlands and Matagorda Bay.

Aliki (Fig. 23), observed with Kinara, Kalypso, and Pointed Finger, also exhibited Herd Range I movements. An undetermined portion of Espiritu Santo Bay was included in this dolphin's home

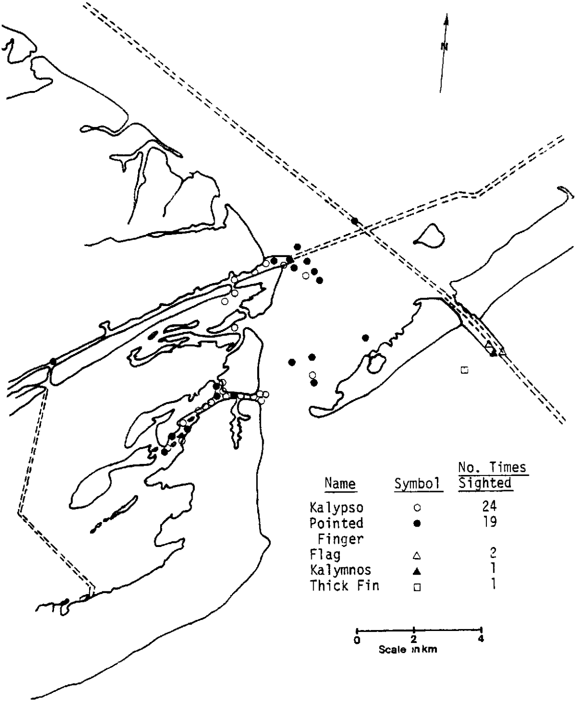


Fig. 22.— Home ranges of several of the "natural tags" which overlapped with the study area.

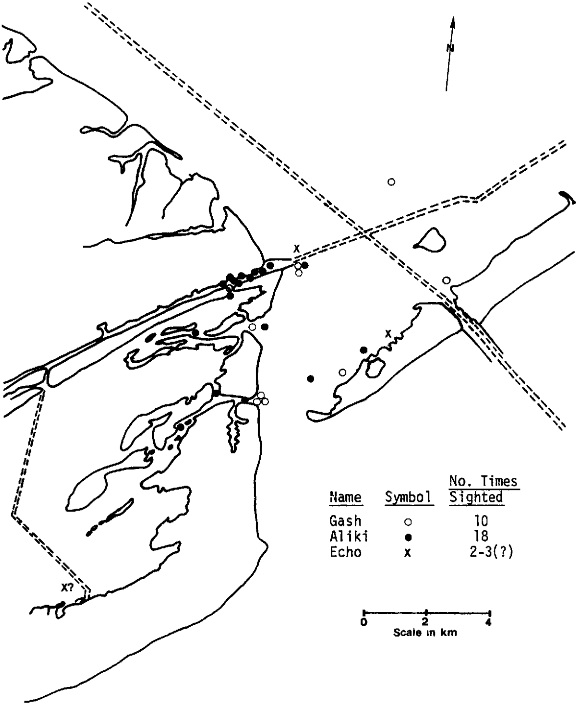


Fig. 23.— Home ranges of several of the "natural tags" which overlapped with the study area.

range. Thirteen out of a total of 18 sightings were recorded in the northwestern portion of Section 6, primarily in the vicinity of the Port O'Connor jetties and Fisherman's Cut. All winter sightings occurred in the above location, although by March, Aliki was observed throughout Section 6. Aliki was seen in the Intracoastal Waterway again on 1 and 2 April, and, like Pointed Finger, alternated between the marshlands and open Bay during the summer.

Gash and her calf (Fig. 23) were seen a total of 10 times during September, October, March, April, and June. Eight of Gash's 10 sightings occurred well within Herd Range I, and she was observed in the company of Kinara, Kalypso, and Aliki upon different occasions. However, two sightings of Gash traveling away from the study area and outside of the study area, as well as her prolonged absence during late fall and throughout the winter, posed questions as to the full extent and seasonal utilization of her range.

Although Tal (Fig. 24) was observed eight times during the study, this dolphin's movements were not monitored prior to March. Tal's home range appeared similar to that of the other "natural tags" found in Herd Range I. Sightings varied among Saluria Bayou, Devil's Elbow, the Intracoastal Waterway, Pass Cavallo, and the northeastern end of Section 2. Two April sightings of Tal with Kalypso expanded Tal's home range southwest into Espiritu Santo Bay.

Ragamuffin (Fig. 24), who was not individually identified until 1 March 1979, was seen in Herd Range I on seven occasions during the spring and summer of 1979. Four of the seven sightings were recorded within 2.6 km of the Port O'Connor jetties. Ragamuffin was noted several meters off the Matagorda Peninsula motte on 29 June 1979, and was noted 10.5 km to the northwest 4 days later. This dolphin's home range is substantially enlarged if one assumes that Tal traveled from Matagorda Bay through either Big Bayou or Saluria Bayou and continued west through Espiritu Santo Bay in order to reach the southeastern end of the Army Cut.

Gil, Antimos, and Huckleberry (Fig. 24) were sighted seven, six, and five times, respectively, within Herd Range I. Movements of these dolphins were monitored between February and July; their where-

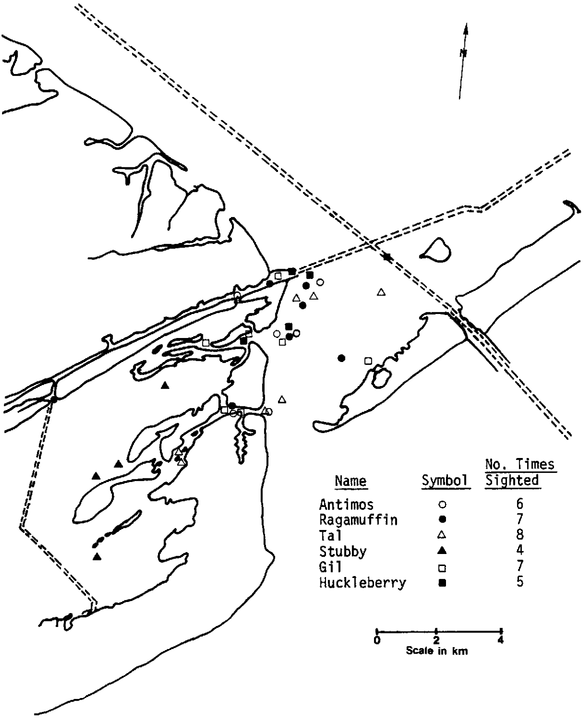


Fig. 24.— Home ranges of several of the "natural tags" which overlapped with the study area.

abouts prior to that period are unknown.

Although Stubby (Fig. 24) was sighted only four times between March and August 1979, all sightings occurred along the western periphery and southwest of Section 6. Speculation that the northeastern edge of Stubby's individual home range overlapped with the southwestern edge of Section 6 increased when Stubby was observed nearly 4 km southwest of the study area with Kinara.

Echo (Fig. 23) was observed once with Huckleberry in June 1979 off the Port O'Connor jetties, and once in July 1979 in the northeastern corner of Section 2. A previous, unconfirmed sighting of Echo was made on 29 October 1978 near the Ferry Channel in Espiritu Santo Bay, 0.5 km west of Matagorda Island and 17 km southwest of the subsequent summer sighting. Observations of Echo are inadequate to offer any further assumptions regarding the extent of its home range.

Ilios and Little Chopped (Fig. 21) were noted five and seven times, respectively, in the northeastern portion of the study site (Herd Range II). Ilios was observed following a shrimp boat with Pointed Finger on 18 December 1978 north of Section 2 in the Matagorda Ship Channel. Little Chopped, a calf, was also observed 1 hour later in the northeastern corner of Section 2. On 10 January 1979, Ilios and Little Chopped were both noted among 30 dolphins in Matagorda Bay that were scattered near the Ship Channel jetties. Subsequent sightings of the two dolphins were recorded primarily along the Matagorda Peninsula and north towards the middle of Matagorda Bay.

Tursiops with distinctive scars, torn fins, and barnacles were usually observed only a single time within or near the ends of the Matagorda Ship Channel jetties (Grid 32) and in the near-shore Gulf of Mexico. Many of these dolphins were so much more distinctively marked than those ordinarily recorded within the study area that they would have easily been recognized had they frequented the study area on a regular basis. It is assumed that they inhabited the near-shore Gulf and occasionally entered Matagorda Bay, either via the Matagorda Ship Channel or Pass Cavallo. Flag (Fig. 22) was sighted in Grid 32 on 28 October 1978 and 29 October 1978. On 29 October, both Flag and

Kalymnos (Fig. 22) were noted in the same area where Flag had been encountered the previous day. It was hoped that subsequent sightings would aid in clarifying the movement patterns of the "Gulf" dolphins both in and out of the study area.

Thick Fin (Fig. 22) was observed following a shrimp boat 0.5 km southwest of the Matagorda Ship Channel jetties in the Gulf on 29 June 1979. Easily recognizable because of an unusually thick, scarred dorsal fin and congenital hunchback, Thick Fin had been initially identified during an earlier study conducted in the Aransas Pass area of Texas, 95 km to the southwest (Shane, 1977; Shane and Schmidly, 1978). Although he had been regularly observed throughout 1976-1977, it was assumed that Thick Fin had a second home range elsewhere because he was seen only a single time that winter (25 January 1977). Thick Fin was therefore also included as a "natural tag" during this study because of the multitude of questions regarding home range, movements, social structure, and inshore/offshore distribution which the single sighting precipitated. During the summer of 1979, Thick Fin was seen by several Port Aransas ferry operators on 24 June 1979, and, although he may have returned to the area, was not noted again until 22 July 1979. It was during that interval that he was sighted near the Matagorda Ship Channel jetties. It is not known whether Thick Fin moved farther offshore during any segment of his absence from the Aransas Pass area, if his movements were largely limited to the near-shore area between the Aransas Pass jetties and the Matagorda Ship Channel jetties, or if he continued still farther northeast of the Ship Channel jetties before returning to Aransas Pass.

Seasonal Movements

Seasonal movement patterns were generated by reviewing "natural tag" movements and by comparing estimated population density among the six sections through the year. Some "natural tags" were seen consistently in the same regions of the study area throughout the year, and others, although sighted on a less frequent basis, were also recorded in the same areas from one encounter to the next. This led to the initial impression that most of the "naturally tagged" *Tursiops* were resident animals whose movements were fairly localized in and around the study area. The repeated sightings, which gave the appearance of limited movement and consistent location, were generally too sparse to assure that extensive travel between sightings did not occur.

"Natural Tag" Seasonal Movements

Kinara, regularly found in the southwestern region of Section 6 (Saluria Bayou and Devil's Elbow) during the fall and winter, was primarily sighted in Matagorda Bay during late spring and summer. Kalypso was sighted in and around the Intracoastal Waterway and Saluria Bayou as well as farther northeast in Matagorda Bay during the spring. Pointed Finger, found in Pass Cavallo and Matagorda Bay during the fall, winter and summer, frequented Saluria Bayou and Devil's Elbow during the spring. Winter observations of Aliki were concentrated in the Intracoastal Waterway near Fisherman's Cut. During the spring and summer, Aliki was seen throughout the Section 6 area, including the Port O'Connor jetties, Fisherman's Cut, Big Bayou, and Devil's Elbow. One spring and one summer sighting in Matagorda Bay near the southwestern corner of Matagorda Peninsula were recorded. Kalypso was noted three times in September and was not observed again until December, after which sightings were recorded once a month until March. Because Kalypso was known to range into Espiritu Santo Bay, and because several March sightings consisted of Kalypso traveling from Devil's Elbow into Espiritu Santo Bay, it is possible that this dolphin's winter movements and activities were predominantly confined to that bay.

The resumption of more frequent sightings of Kalypso in March may have been related to the initial sightings of Antimos, Ragamuffin, Tal, and Huckleberry during the same period. Sightings of Gil were recorded only during the spring. Stubby, initially sighted during March, was observed during the spring and summer along the southwestern periphery of the study area, as well as outside it. Fall and winter movements may have been concentrated farther southwest of the study area.

Ilios was observed during the fall, winter, and summer, and Little Chopped was sighted during all four seasons of 1978-1979 as well as after the study's formal conclusion. Three of Ilios' four fall sightings were recorded in Section 4, while the fifth sighting, during the summer, was recorded farther southwest along the Peninsula shoreline. Fall and winter sightings of Little Chopped were recorded near the Ship Channel jetties and northeast along the Peninsula to the bulkhead. Two other sightings were recorded northwest of Section 4. The single spring sighting of Little Chopped occurred on 25 April 1979 when the calf was noted in a large herd that was following a shrimp boat 11.7 km north of the bulkhead. At the end of the summer of 1979, Little Chopped was sighted several hundred meters north of the bulkhead. Two more sightings of the calf were made in that area during the fall following the study's conclusion.

Ourania, sighted during all four seasons, was observed only once during the winter and once during the spring of 1979. Because she was seen so rarely and was known to frequent Powderhorn Lake, it was assumed that her movements were concentrated in Powderhorn Lake and farther north and northwest in Matagorda Bay.

According to Shane (1977) and Shane and Schmidly (1978), although Thick Fin was noted around Aransas Pass during all four seasons of 1976-1977, he was seen only a single time during the winter. The observation of Thick Fin outside the Matagorda Ship Channel jetties on 29 June 1979 was a chance encounter because that area was rarely covered. It is not known how many, or if, in fact, all, of Thick Fin's absences from the Aransas Pass area may be traced to the Pass Cavallo-Matagorda Ship Channel area.

Seasonal Variation in Estimated Population Density

Estimated fall density was highest in Sections 3, 4, and 1, the Matagorda Ship Channel (particularly in Grid 32 and Grids 27, 28, and 29 adjacent to Section 5 where fall shrimping activity was common), the near-shore area northeast of the Matagorda Ship Channel, and Pass

Cavallo. Dolphins also concentrated along the Matagorda Peninsula southwest of the Ship Channel, as well as in and around the mouth of Big Bayou, the Army Cut-Intracoastal Waterway intersection, inside and at the mouth of the Port O'Connor jetties, and northwest of the jetties along the shoreline to the harbor of Indianola.

Estimated dolphin sensities peaked during the winter and were highest in Sections 3, 4, and 1. Most dolphins in Section 1 were observed at the point of intersection of Saluria Bayou and the Pass, at the northeastern tip of Matagorda Island, and at the southwestern tip of Matagorda Peninsula (Decros Point). Although the total 16 km^2 area of Section 6 ranked fourth in overall estimated winter density, more dolphins were seen in Section 6 in February than were seen in any other section of the study area with the exception of the Matagorda Ship Channel. Mean density in and around the mouths of the Port O'Connor jetties and in the 2.7 km stretch of Saluria Bayou and Devil's Elbow exceeded the density observed in the remainder of the section and was higher than any other similarly-sized region of the study area. During mid-winter, 20 to 25 dolphins were regularly observed in Saluria Bayou. This dramatic winter increase of dolphins in the area of communication between Pass Cavallo and Saluria Bayou and southwest along the length of the Bayou to Devil's Elbow, was noted along with isolated, sporadic incidents of herds of 20 to 30 dolphins traveling northeast and southwest between the Port O'Connor jetties and Fisherman's Cut, and southwest into Barroom Bay. A brief, 2-week mid-winter concentration of Tursiops was also observed in the Intracoastal Waterway during a mullet run.

Few dolphins were sighted in Section 5 during the winter. Dolphin sightings in Section 2, although double the fall value, were erratic and continued to be so through the spring and summer. Observations ranged from a few, scattered individuals, to herds of 15 to 30 dolphins in the northeastern corner of Section 2 near oil platforms and midway along the Peninsula between Decros Point and the Matagorda Ship Channel.

Few dolphins were seen in the study area during the spring. Although an increase in movement from Saluria Bayou and Devil's Elbow southwest into Espiritu Santo Bay was noted during the spring, estimated density from February to March decreased by half in Sections 1 and 6, and by a factor of eight in Section 4. Dolphin density in Section 3 declined from 3.47 ± 0.566 Tursiops/km^2 (winter) to 2.96 ± 2.15 Tursiops/km^2 (spring). No dolphins were found in Sections 4 or 5 during April, and only Section 2 exhibited an increase (0.551 ± 0.36 Tursiops/km^2 to 0.849 ± 0.24 Tursiops/km^2). Sections 3, 1, and 6 exhibited highest overall density. Section 5 exhibited its lowest density of the year during this time.

Summer dolphin sightings in Section 5 were triple what they had been during the spring. A decrease was noted in Section 6, a slight increase was evident in Section 3, and Sections 1, 2, and 4 remained fairly constant. Large declines in dolphin numbers in Sections 2 and 6 occurred from July to August, whereas the summer increase of dolphins observed in Section 5 was mainly due to a large July to August increase.

Daily Movements

General observations, short-term movement patterns of "naturally tagged" Tursiops, and 65 "following" maps of both "naturally tagged" and unidentified dolphins offered insight into daily movements. A review of "natural tag" movements within a single day, among consecutive days, and from one period of sightings until the next, portrayed the variable nature of short-term movements.

"Time-Group" Sightings

Table 7 presents 34 groups of "natural tag" sightings in which an interval of 3 days or less between sightings of the same dolphin occurred. Movements were relatively localized, and sighting locations from one encounter to the next did not exceed a distance of 10 km. Seventy-nine percent of the "time-groups" were composed of consecutive sightings in which the "natural tag" was found less than 5 km from its last sighting. Periods between one "time-group" of consecutive

TABLE 7.— "Time-Group" sightings: sighting dates and locations of "natural tags" in which an interval of 3 days or less between sightings of the same dolphin occurred.

	Date	Location
Kinara	31 October	Saluria Bayou/Devil's Elbow
	3 November	Saluria Bayou
	4 November	Saluria Bayou/Mitchell's Cut
	7 November	Saluria Bayou/Mitchell's Cut
	11 January	Saluria Bayou (U.S.C.G. ruins)
	15 January	Saluria Bayou (Mitchell's Cut
	12 February	Saluria Bayou/Devil's Elbow
	14 February	Devil's Elbow
	24 February	Saluria Bayou
	28 February	Port O'Connor Jetties
	3 March	Mitchell's Cut
	17 March	Saluria Bayou (U.S.C.G. ruins)
	19 March	Devil's Elbow
	20 March	Devil's Elbow
	24 March	Saluria Bayou
	26 March	Mitchell's Cut
	30 March	Devil's Elbow
	1 April	Saluria Bayou/Mitchell's Cut
	18 April	Saluria Bayou/Mitchell's Cut
	19 April	Port O'Connor Jetties
	25 April	Saluria Bayou
	27 April	Saluria Bayou
	15 May	Decros Stake, Matagorda Bay
	16 May	Matagorda Peninsula Mott
	17 May	Decros Point area, Matagorda Bay
Kalypso	23 September	Saluria Bayou
	24 September	Mitchell's Cut/Saluria Bayou
	3 March	Devil's Elbow
	4 March	Saluria Bayou
	17 March	Saluria Bayou (U.S.C.G. ruins)
	19 March	Saluria Bayou/Mitchell's Cut
	22 March	Intracoastal Waterway (Clark's Fish House)
	28 March	Saluria Bayou/Mitchell's Cut
	29 March	Devil's Elbow/Bayucos Point
	1 April	Big Bayou/Mailboat Point
	6 April	Saluria Bayou (U.S.C.G. ruins)
	7 April	Saluria Bayou/Bayucos Point

TABLE 7 (Continued).

	Date	Location
Kalypso (Cont.)	17 July	Decros Stake, Matagorda Bay
	21 July	NE Little Old Jetties, Pass Cavallo
Gash	16 September	Big Bayou/Matagorda Bay
	18 September	Matagorda Peninsula Corral
	3 March	Saluria Bayou/Pass Cavallo
	4 March	Saluria Bayou/Pass Cavallo
	5 March	Saluria Bayou/Pass Cavallo
	26 March	Port O'Connor Jetties
	1 April	Barroom Bay/Fisherman's Cut/ Intracoastal Waterway
Ourania	25 June	Matagorda Ship Channel
	26 June	NE Indianola Harbor/Matagorda Ship Channel
Flag	28 October	Matagorda Ship Channel/Gulf of Mexico
	29 October	Matagorda Ship Channel/Gulf of Mexico
Pointed Finger	23 November	Port O'Connor Jetties
	25 November	Port O'Connor Jetties
	18 December	Matagorda Ship Channel (N Section 2)
	20 December	Pass Cavallo (N Saluria Bayou/ Pass Cavallo intersection)
	28 March	Saluria Bayou/Mitchell's Cut
	29 March	Devil's Elbow
Little Chopped	18 December	Section 2 Oil Platforms
	19 December	NE Section 4
	10 January	Section 2 Oil Platforms/Matagorda Ship Channel Jetties
	12 January	Matagorda Peninsula shoreline towards bulkhead
Aliki	12 February	Intracoastal Waterway/Fisherman's Cut
	15 February	Intracoastal Waterway/Fisherman's Cut
	14 March	Port O'Connor Jetties
	17 March	Big Bayou/Mailboat Point

TABLE 7 (Continued).

	Date	Location
Aliki (Cont.)	20 March	Devil's Elbow
	24 March	Intracoastal Waterway (Clark's Fish House)
	25 March	Matagorda Peninsula Mott
	1 April	Intracoastal Waterway (Fisherman's Cut)
	2 April	Intracoastal Waterway (Clark's Fish House)
	6 June	Port O'Connor Jetties
	8 June	Saluria Bayou
Antimos	8 June	Saluria Bayou/Mitchell's Cut
	12 June	NE Big Bayou/Matagorda Bay
Ragamuffin	29 June	W Bay Stake (Matagorda Bay)
	3 July	Army Cut
	20 July	Port O'Connor Jetties
	24 July	Port O'Connor Jetties
Gil	20 March	Saluria Bayou/Mitchell's Cut
	22 March	Barroom Bay/Big Bayou
	25 March	Matagorda Peninsula Mott
	16 April	Little Mary's Stake, Big Bayou
	18 April	Intracoastal Waterway/Port O'Connor Jetties
Huckleberry	9 June	Matagorda Ship Channel
	13 June	Port O'Connor Jetties

sightings until the next "time-group" varied from 6 days (Kalypso) to 6 months (Gash); however, animals were found within 5 km of their last "time-group" sighting 82% of the time.

Examples of "naturally tagged" dolphin movements from one sighting to the next during longer intervals revealed much movement throughout the study area, as well as the prolonged, concentrated coverage of certain sites. Between 9 March and 20 March 1979, Aliki traveled from Saluria Bayou to the Port O'Connor jetties to the west end of Big Bayou and back through Saluria Bayou into Devil's Elbow. Four days later, Aliki was observed in the Intracoastal Waterway near the jetties, and was found 9 km from the jetties on the following day. Six days later, on the morning of 1 April, Aliki was sighted once again in the Intracoastal Waterway, and during the following afternoon was found within 0.5 km of the previous day's sighting. Aliki may or may not have left the immediate area during the 24-hour period between sightings, and the chance that extensive travel may have occurred cannot be ruled out.

The consecutive sightings of Gash and her calf on 3, 4, and 5 March at the mouth of Saluria Bayou are an example of the heavy, temporary use of particular areas. Then, on 26 March and on 1 April, Gash and her calf were recorded at the ends of the Port O'Connor jetties and in the area of the Intracoastal Waterway and Fisherman's Cut. It is very possible that extensive movements occurred during that 5-day period, because during a similar interval, for example, Thick Fin traveled at least 95 km.

Predictable movement patterns were noted for several days, after which an abrupt shift or change in location occurred. Very few dolphins were noted in the Intracoastal Waterway during January and February. During a brief mullet run, large pods consistently appeared to herd mullet in a cooperative fashion in the Waterway between the Port O'Connor jetties and the U. S. Coast Guard Station. Two weeks later, few dolphins were noted in that area. During March, for example, considerable movement between the northeast end of Saluria Bayou to Devil's Elbow and west into Espiritu Santo Bay was evident. By April, dolphins were rarely seen in those areas.

"Following" Maps and Short-Term Travel

"Following" maps (Figs. 25-28) depicted the movements of dolphins trailed from a few minutes to over 2 hours. The maps, representative of the most commonly observed traveling patterns, helped illustrate the diversity of activity and movements within limited periods of time. Date, time, number of animals followed, and behavior may be found in Table 8.

Four major travel routes were noted: (1) traveling east from the Port O'Connor jetties to the Matagorda Peninsula, (2) northeast or southwest along the Peninsula shoreline, (3) northwest or southeast in Pass Cavallo, and (4) northeast or southwest between Matagorda Bay through the marshlands and into Espiritu Santo Bay. These "travel routes" appeared to constitute arteries between the large, open expanses of water (Matagorda and Espiritu Santo Bays), as well as between the Port O'Connor jetties, Matagorda Peninsula, and Pass Cavallo.

"Travel" was the most frequently recorded behavior (69% of all behavioral observations) (Fig. 29). "Travel" was recorded under circumstances of strong, forward, goal-oriented movement, in addition to slow, often indecisive progression with frequent changes of direction and speed and "random movement" or "milling". Therefore, the percentage of "travel" is somewhat unrealistically inflated since it is not limited to actual goal-oriented forward progression, but includes "random movement" as well.

Even so, it is clear from Figs. 29 and 30 that a majority of the dolphins' time is spent in either progressive travel or random movement (possibly in conjunction with feeding). When the four behaviors of travel, feed, mate, and approach-the-observation-platform are viewed as one unit, a chi-square test revealed a highly significant relationship ($p < 0.0001$) between month and behavior ($\chi^2 = 216.020$, d.f. = 33), season and behavior ($\chi^2 = 729.064$, d.f. = 9), and area and behavior ($\chi^2 = 87.84$, d.f. = 9). Time of day had a significant effect ($p < 0.05$) upon those behaviors ($\chi^2 = 20.11$, d.f. = 9), but tide did not ($p < 0.10$).

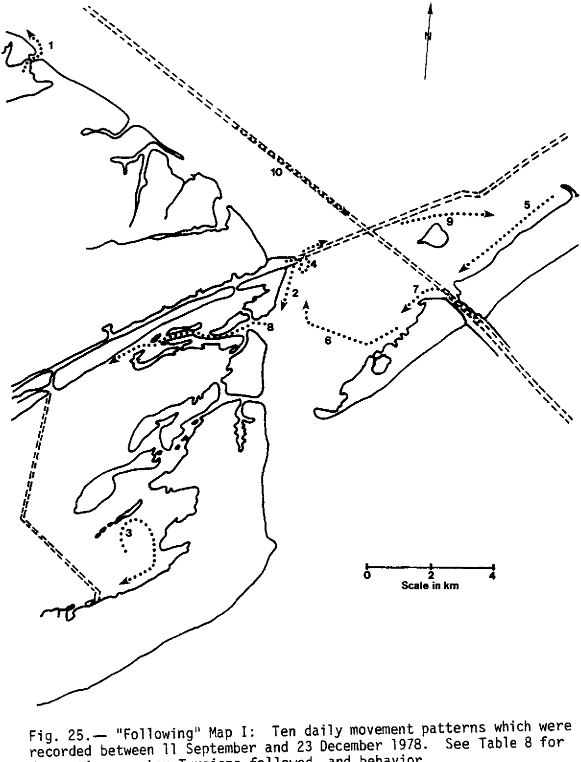


Fig. 25.— "Following" Map I: Ten daily movement patterns which were recorded between 11 September and 23 December 1978. See Table 8 for date, time, number Tursiops followed, and behavior.

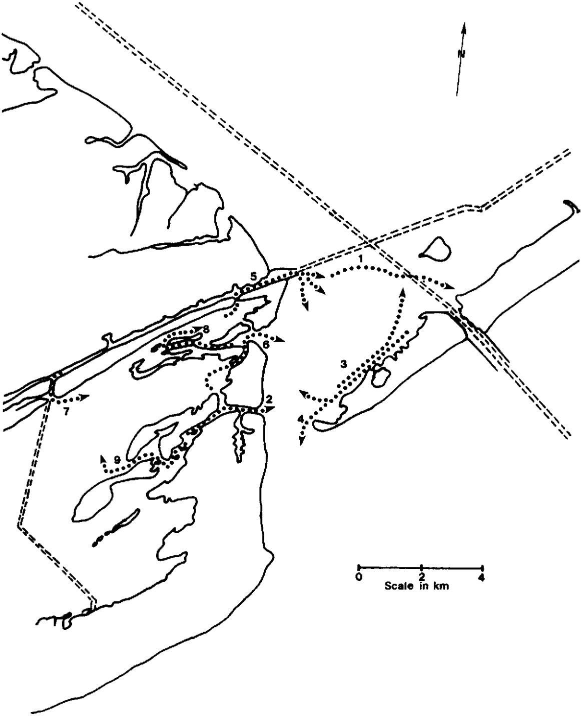


Fig. 26.— "Following" Map II: Nine daily movement patterns which were recorded between 10 January and 3 March 1979. See Table 8 for date, time, number *Tursiops* followed, and behavior.

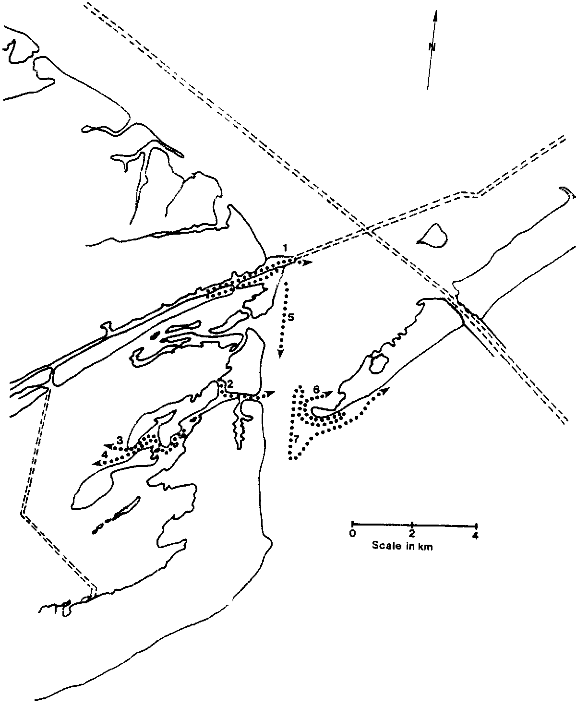


Fig. 27.— "Following" Map III: Seven daily movement patterns which were recorded between 14 March and 27 March 1979. See Table 8 for date, time, number *Tursiops* followed, and behavior.

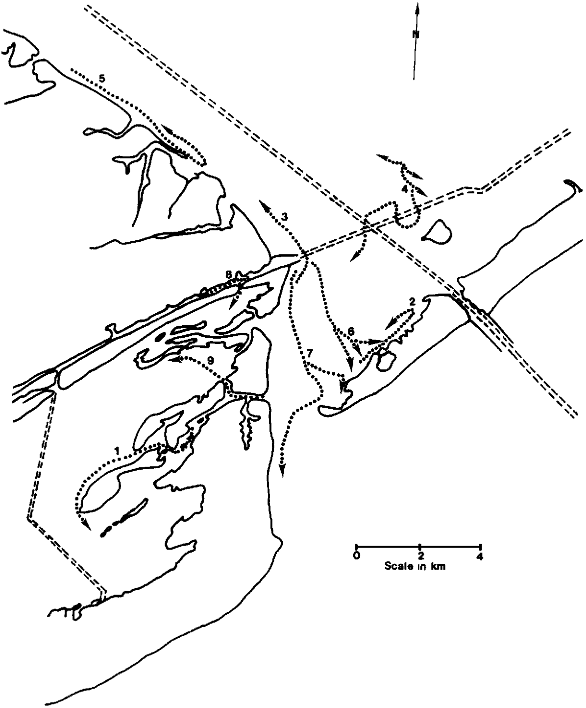


Fig. 28.— "Following" Map IV: Nine daily movement patterns which were recorded between 6 April and 10 August 1979. See Table 8 for date, time, number Tursiops followed, and behavior.

TABLE 8.— "Following" map data including date, time, number of *Tursiops* followed, and behavior.

"Following" Map I

Date	Time	*Tursiops*	Behavior
1. 9/11	0700-0733	Ourania + calf	traveling/feeding
2. 9/17	1600-1700	15	traveling/mating
3. 9/20	1015-1230	4	traveling/mating
4. 9/30	1605-1615	4	traveling/riding bow-wave
5. 10/2	1333-1500	15	traveling
6. 10/5	1135-1311	10	traveling
7. 10/19	1537-1615	4	traveling
8. 11/25	1425-1445	4	traveling/feeding
9. 12/19	1240-1303	Little Chopped + 15	traveling
10. 12/23	1100-1215	13	traveling

"Following" Map II

Date	Time	*Tursiops*	Behavior
1. 1/10	1120-1230	Pointed Finger + 2	traveling
2. 1/19	1425-1525	2	traveling
3. 1/22	1115-1210	4	traveling
4. 1/24	1530-1700	Pointed Finger + 20	traveling
5. 2/6	1700-1800	25	traveling
6. 2/12	1345-1406	Kinara + 2	traveling
7. 2/15	1205-1230	9	traveling
8. 2/15	1425-1445	1	traveling
9. 3/13	1015-1115	3	traveling

TABLE 8 (Continued).

Date	Time	"Following" Map III Tursiops	Behavior
1. 2/14	1120-1235	2	traveling/feeding
2. 3/19	1645-1702	Pointed Finger + Kalypso	traveling
3. 3/20	0935-1020	Aliki + 3	traveling
4. 3/20	1025-1041	Stubby + 3	traveling
5. 3/26	1655-1723	20	traveling
6. 3/27	1100-1117	3	traveling
7. 3/27	1125-1230	15	traveling/mating

Date	Time	"Following" Map IV Tursiops	Behavior
1. 4/6	0935-1040	Stubby + 8	traveling
2. 5/15	1215-1310	15	traveling/randomly moving
3. 6/1	1050-1140	9	traveling/mating
4. 6/9	1150-1230	Gash + calf + 1	traveling/randomly moving/feeding
5. 6/16	1520-1700	2	traveling
6. 6/27	1715-1900	25	traveling
7. 7/21	0950-1120	10	traveling
8. 8/7	1930-2100	7	traveling
9. 8/10	1555-1620	3	traveling

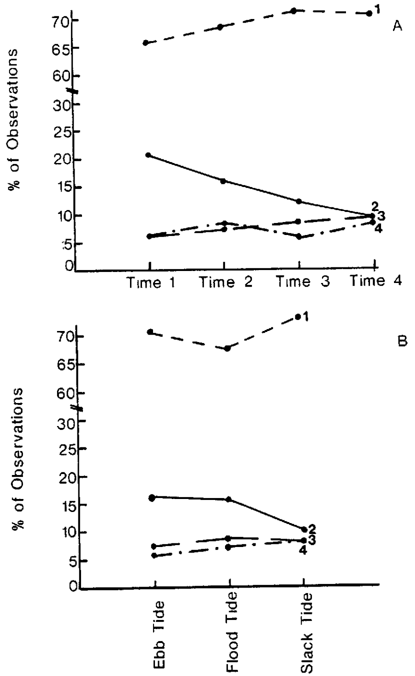


Fig. 29.— Variation in percent of observations of (1) traveling, (2) feeding, (3) mating, and (4) approaching the observation platform according to (A) time of day and (B) tide.

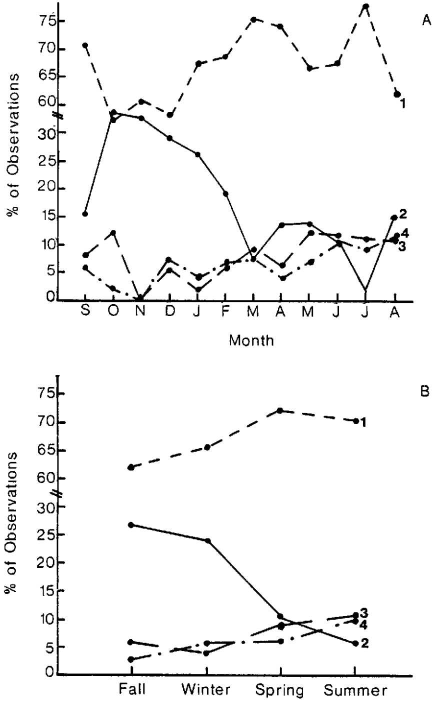


Fig. 30.— (A) Monthly and (B) seasonal percentage of observations of (1) traveling, (2) feeding), (3) mating, and (4) approaching the observation platform.

Spatial Organization

The most striking example of intentional, directed group movement was exhibited in the form of "porpoise parades". Pods of three to five dolphins strung themselves out in a long, narrow line, often 1 to 2 km in length. Pod distances remained consistent as the line slowly progressed forward. The fluidity and intermingling among pods so often seen in other movement patterns and under other circumstances was absent, and pod structure remained stable and intact. As many as 20 to 40 Tursiops traveled in strong, goal-oriented movement, often covering several kilometers within an hour. "Porpoise parades" were recorded most often along the length of the Matagorda Peninsula, although they were also observed in the Intracoastal Waterway (usually moving in a northeasterly direction towards Matagorda Bay), and in Pass Cavallo (moving in a southerly direction towards the Gulf of Mexico).

A second movement type and herd configuration involved entire herds which moved "en masse" and were assembled in dynamic, fluid pods that were more difficult to differentiate. The herd appeared less structured and progressed more as a single, large unit of intermingling pods. This type of organization was most often observed in conjunction with feeding and mating.

A third type of herd configuration resembled a hollow oval. This structure was rarely observed.

Generally speaking, fluid pod structure was most evident during periods of random movement and milling, mating, and playing. Frequent transit of individuals from pod to pod, coupled with the high degree of interaction among pods, made it difficult to determine pod integrity.

Oil Spill

An oil spill occurred in the Port O'Connor area in September 1978, raising serious questions concerning effects upon the general health, behavior, and short-term movements of dolphins which might come into contact with contaminated areas. On 25 September 1978 at 0120 h, the towboat "Dixie Volunteer" ran aground on shoals around a dredging platform located approximately 4.8 km northeast of the Port O'Connor jetties. The towboat ran aground while pushing three 61-m barges that were bound for Lake Charles, Louisiana, with a load of Number Six fuel oil. An estimated 11,356 l of fuel oil washed onto nearby shores. One large oil slick approximately 0.5 km long and 247 m wide polluted the Port O'Connor jetties and Intracoastal Waterway southwest towards Fisherman's Cut, while several deposits of oil were found around the mouth of Big Bayou to the south and Boggy Bayou to the northwest. Large concentrations of 5 to 7.5 cm thick oil accumulated in the marshlands immediately northwest of the Port O'Connor north jetty.

Areas where the oil had accumulated were known to be regularly frequented by dolphins. Although the Intracoastal Waterway inside the jetties was still extremely polluted by Wednesday, 27 September, 20 dolphins including one calf were found in the areas of heaviest oil concentrations. The animals swam back and forth through the large oil globules and most severely contaminated areas, seemingly unaffected by the oil as they repeatedly surfaced in the midst of the thickest concentrations. Most striking was the overwhelming atmosphere of play. Animals continuously mated, leaped, body-surfed on the small swells, trunk- and tail-slapped, and tossed fish back and forth to one another. Fish were held in the dolphins' mouths for several moments before being tossed to other dolphins. Although fish-tossing had been observed several times prior to the oil spill, and was seen periodically thereafter, upon no other occasion was this activity as prevalent and conspicuous as it was immediately following the oil spill.

The jetties area was checked three times during that day, at 1000 h, at 1300 h, and 1800 h. Special efforts were undertaken to identify individuals so that the amount of time spent in the area might be compared with the dolphins' presence there during more typical days. Although oil had polluted the areas around both the north and south jetties, the majority of dolphins were scattered up and down the inside of the north jetty, precisely where the oil slicks were most abundant. One dolphin that was identified at 1025 h was resighted in the same area at 1315 h with 13 other _Tursiops_ that were still tossing fish and playing. The jetties were checked a third time at

1800 h, and although the uniquely-scarred dolphin seen earlier during the day was absent, 15 other dolphins were mating, surfing, and tossing fish.

A "norther" blew in on Thursday, 28 September, preventing coverage of the jetties. On 29 September, five Tursiops were observed outside and to the south of the south jetty. During a morning aerial survey on Saturday, 30 September, no dolphins were recorded inside the jetties and few dolphins were seen throughout most of the study area. Oil slicks covered much of Sections 1 and 2. However, 44 dolphins were sighted from the project boat in Sections 2 and 4 later that afternoon.

Bay-Gulf Interchange

Dolphins were never observed traveling the entire distance from any point in Matagorda Bay through the Matagorda Ship Channel jetties and into the Gulf of Mexico, or vice versa. Dolphins were sometimes sighted in Matagorda Bay near the Ship Channel jetties (Grids 26 and 33) and were followed into the jetties, but were lost in the swells or in the aftermath of their approach towards incoming or outgoing vessels. Other dolphins which were sighted midway through the jetties (Grids 31 and 32) and followed out to the Gulf were not known to have frequented Matagorda Bay. Still other animals observed at the ends of the jetties in the Gulf were never noted entering the jetties and the Bay.

Dolphins were seen in Pass Cavallo, within Matagorda Bay adjacent to the Pass, and farther within the Bay traveling towards the Pass. They were also observed near the northeastern tip of Matagorda Island, far out in the Pass. Two incidents suggest that an undetermined amount of exchange between the Bay and Gulf does exist. The first incident, on 27 March 1979, involved a herd of 15 dolphins (including a newborn calf flanked by adults on either side and several juveniles to the rear of the herd) that traveled along the Matagorda Peninsula Gulf beach, around the tip of Decros Point, north into the Pass, and into the edge of Matagorda Bay. They returned to the Gulf within 45 minutes of their initial sighting and were followed an additional 2 km as they continued northeast along the Peninsula Gulf shoreline towards the Matagorda Ship Channel jetties.

The second incident occurred on 7 July 1979 when 10 Tursiops were followed from 0950 h until 1120 h as they traveled from just outside the Port O'Connor jetties towards Decros Point. Although the herd separated into several pods, the majority of which traveled northeast along the Matagorda Peninsula bay shoreline, a pod of four animals was followed down the Pass and into the Gulf.

Influence of Tidal Flow and Time of Day

Dolphins moved against the tidal flow significantly more often than they moved with the flow (Chi-Square Test, $\chi^2 = 15.226$, d.f. = 4, $p < 0.005$). They were more likely to move randomly during an ebb tide than during a flood tide. Southeasterly movements were more common during flood tides, and northwesterly movement was more predominant during an ebb tide.

When the day was divided into four time periods (I: 0600 - 1000 h; II: 1000 - 1300 h; III: 1300 - 1700 h; IV: 1700 - 2100 h), significantly more northwest-southeast movement was recorded during Time I ($\chi^2 = 29.02$, d.f. = 12, $p < 0.005$). Time II movements tended to be either random or in a northerly direction, and Time III movements were most often noted to the southeast or were random. Time IV movements predominated to the southwest.

Social Composition

"Naturally Tagged" Dolphins

The majority of "natural tags" appeared to belong to one of three extended herds. When the 96 incidents of "natural tag" associations are reviewed, 18 of the 20 "naturally tagged" dolphins were observed in the company of one or more other "natural tags" from one to 15 times, with a mean of 5.3 times. With one exception, animals which were assumed to be members of one extended herd were never seen associating with animals of another extended herd.

Table 9 lists the date, location, and type association among "natural tags". The types of associations included "pod member", "herd member", or "located in vicinity", i.e., within 1.0 to 1.5 km of another "natural tag". Pod composition tended to be fluid and dynamic, and "natural tags" repeatedly interacted with the same, recognizable individuals over time as well as with other dolphins that had not been identified. The manner of association and degree of intimacy was variable. Animals observed as pod members during one encounter were each noted interacting with different animals during other encounters, although previous pod members were recorded in the vicinity. "Natural tags" were documented as herd members or within the same vicinity of other "natural tags" 74% of the time. In several cases, those "naturally tagged" dolphins which were seen most frequently in the same herds or vicinity of other "natural tags" tended to be the pod members as well.

Kinara associated with the largest number of other "natural tags", including three times each with Kalypso and Gil, twice each with Antimos, Pointed Finger, and Stubby, and a single time each with Gash, Aliki, and Ragamuffin. Kinara was noted once in the same pod and twice within the same vicinity as Gil, once in the same herd and twice in the same vicinity as Kalypso, and only once in the same herd as Aliki. The seven "natural tags" with which Aliki was noted were the same animals that were seen with Kinara, although Aliki was not seen with Ragamuffin. Although Kinara was observed in the same pod only once with Gil and once with Stubby, pod members among Aliki's various encounters included Gil, Antimos, Pointed Finger, and Kalypso.

Kalypso was noted alone upon three occasions, and was sighted with six "naturally tagged" dolphins (Aliki, Kinara, Gash, Pointed Finger, Stubby, and Tal) among several encounters. Kalypso and Pointed Finger were noted in the same pod three of the four times in which they were sighted together. This was the only case in which two _Tursiops_ were observed within the same pod more than once. Pointed Finger's presence within the same herd as Ilios, as well as this

TABLE 9.— Associations of "naturally tagged" *Tursiops* with one another. Listed are dates and locations of joint sightings and type of association (pod, herd, or vicinity).

	Date	Location	Type
Sea Wolf			
Ourania	6-26-79	Matagorda Ship Channel, off Powderhorn Ranch (Grid 27)	vicinity
Kinara			
Antimos	2-28-79	Southeast of Port O'Connor jetties (Grid 15)	herd
	3-24-79	Saluria Bayou (U.S.C.G. ruins) (Grid 82)	herd
Gash	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
Kalypso	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
	3-17-79	Saluria Bayou/Pass Cavallo (Grid 8)	herd
	3-19-79	Devil's Elbow (Grid 85)	vicinity
Pointed Finger	3-19-79	Devil's Elbow (Grid 85)	vicinity
	6-25-79	Matagorda Peninsula Mott (Grid 24)	vicinity
Aliki	3-20-79	Devil's Elbow (Grid 85)	herd
Stubby	3-20-79	Devil's Elbow (Grid 85)	vicinity
	8-30-79	Southeast of Farwell Island (Grid 88)	pod
Gil	3-20-79	Devil's Elbow (Grid 85)	vicinity
	4-27-79	Saluria Bayou/Devil's Elbow (Grid 85)	pod
	5-5-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
Ragamuffin	5-22-79	Southeast of Little Old Jetties (Grid 15)	herd
Gash			
Kalypso	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
Kinara	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
Kalypso	3-4-79	Saluria Bayou/Pass Cavallo (Grid 8)	herd
Aliki	4-1-79	Intracoastal Waterway/Fisherman's Cut (Grid 65)	herd

TABLE 9 (Continued).

	Date	Location	Type
Gash	4-1-79	Intracoastal Waterway/Fisherman's Cut (Grid 64)	herd
Pointed Finger	7-17-79	Northwest of Decros Stake, Matagorda Bay (Grid 17)	pod
Little Chopped			
Pointed Finger	12-18-78	Matagorda Ship Channel southeast of 23/24 (Grid 29)	vicinity
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 30)	herd
Ilios	12-18-78	Matagorda Ship Channel southeast of 23/24 (Grid 29)	vicinity
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 30)	herd
	2-28-79	1 km northeast of Matagorda Ship Channel jetties (Grid 34)	vicinity
Antimos			
Aliki	2-12-79	Intracoastal Waterway/Fisherman's Cut (Grid 64)	herd
	6-8-79	Saluria Bayou (Grid 82)	pod
Kinara	2-28-79	Southeast of Port O'Connor jetties (Grid 15)	herd
	3-24-79	Saluria Bayou (U.S.C.G. ruins) (Grid 82)	herd
Ragamuffin			
Kinara	5-22-79	Southeast of Little Old Jetties (Grid 15)	herd
Tal	8-6-79	Southeast of Little Old Jetties (Grid 15)	vicinity
Tal			
Kalypso	4-7-79	Devil's Elbow (Grid 85)	herd
	4-16-79	Devil's Elbow (Grid 85)	pod
Ragamuffin	8-6-79	Southeast of Little Old Jetties (Grid 15)	vicinity
Stubby			
Kinara	3-20-79	Devil's Elbow (Grid 85)	vicinity
	8-30-79	Southeast of Farwell Island (Grid 88)	pod
Aliki	3-20-79	Devil's Elbow (Grid 85)	vicinity

TABLE 9 (Continued).

	Date	Location	Type
Kalypso			
Aliki	12-4-78	Intracoastal Waterway near Clark's Fish House (Grid 64)	herd
	7-17-79	Northwest of Decros Stake, Matagorda Bay (Grid 17)	pod
Kinara	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
	3-17-79	Saluria Bayou/Pass Cavallo (Grid 8)	herd
	3-19-79	Devil's Elbow (Grid 85)	vicinity
Gash	3-3-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
	3-4-79	Saluria Bayou/Pass Cavallo (Grid 8)	herd
Pointed Finger	3-19-79	Saluria Bayou/Mitchell's Cut (Grid 83)	pod
	3-28-79	Saluria Bayou/Mitchell's Cut (Grid 83)	pod
	3-29-79	Devil's Elbow (Grid 85)	herd
	7-12-79	Northwest of Decros Stake, Matagorda Island (Grid 17)	pod
Stubby	4-6-79	Saluria Bayou (U.S.C.G. ruins) (Grid 82)	vicinity
Tal	4-7-79	Devil's Elbow (Grid 85)	herd
	4-16-79	Devil's Elbow (Grid 85)	pod
Ourania			
Sea Wolf	6-26-79	Matagorda Ship Channel off Powderhorn Ranch (Grid 27)	vicinity
Flag			
Kalymnos	10-29-78	Ends of Matagorda Ship Channel jetties (Grid 32)	pod
Kalymnos	10-29-78	Ends of Matagorda Ship Channel jetties (Grid 32)	pod
Echo			
Huckleberry	6-13-79	Port O'Connor jetties (Grid 63)	herd
Pointed Finger			
Ilios	12-18-78	Matagorda Ship Channel southeast of 23/24 (Grid 29)	herd
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 30)	vicinity

TABLE 9 (Continued).

	Date	Location	Type
Little Chopped	12-18-78	Matagorda Ship Channel southeast of 23/24 (Grid 29)	vicinity
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 26)	herd
Kalypso	3-19-79	Saluria Bayou/Mitchell's Cut (Grid 83)	pod
	3-28-79	Saluria Bayou/Mitchell's Cut (Grid 83)	pod
	3-29-79	Devil's Elbow (Grid 85)	herd
	7-17-79	Northwest of Decros Stake, Matagorda Bay (Grid 17)	pod
Kinara	3-19-79	Devil's Elbow (Grid 17)	vicinity
	6-25-79	Matagorda Peninsula Mott (Grid 24)	vicinity
Aliki	7-17-79	Northwest of Decros Stake, Matagorda Bay (Grid 17)	pod
Huckleberry	7-22-79	Ends of Port O'Connor jetties (Grid 63)	vicinity
<u>Ilios</u>			
Pointed Finger	12-18-78	Matagorda Ship Channel southeast of 23/24 (Grid 29)	herd
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 30)	vicinity
Little Chopped	12-18-79	Matagorda Ship Channel southeast of 23/24 (Grid 29)	vicinity
	1-10-79	Matagorda Bay/Matagorda Ship Channel jetties (Grid 30)	herd
	2-28-79	1 km northeast of Matagorda Ship Channel jetties (Grid 34)	vicinity
<u>Aliki</u>			
Kalypso	12-4-78	Intracoastal Waterway near Clark's Fish House (Grid 64)	herd
	7-17-79	Northwest of Decros Stake, Matagorda Bay (Grid 17)	pod
Antimos	2-12-79	Intracoastal Waterway/Fisherman's Cut (Grid 64)	herd
	6-8-79	Saluria Bayou (Grid 82)	pod
Kinara	3-20-79	Devil's Elbow (Grid 85)	herd
Stubby	3-20-79	Devil's Elbow (Grid 85)	vicinity
Gil	3-20-79	Devil's Elbow (Grid 85)	vicinity
	3-25-79	Matagorda Peninsula Mott (Grid 24)	pod

TABLE 9 (Continued).

	Date	Location	Type
Huckleberry	6-26-79	Northwest of Mitchell's Cut (Grid 80)	vicinity
Gil	3-20-79	Devil's Elbow (Grid 85)	vicinity
	4-27-79	Saluria Bayou/Devil's Elbow (Grid 8)	pod
	5-5-79	Saluria Bayou/Pass Cavallo (Grid 8)	vicinity
Aliki	3-20-79	Devil's Elbow (Grid 85)	vicinity
	3-25-79	Matagorda Peninsula Mott (Grid 24)	pod
Stubby	3-20-79	Devil's Elbow (Grid 85)	vicinity
Huckleberry			
Echo	6-13-79	Port O'Connor jetties (Grid 63)	herd
Stubby	6-26-79	Northwest of Mitchell's Cut (Grid 80)	vicinity
Pointed Finger	6-22-79	Ends of Port O'Connor jetties (Grid 63)	vicinity

dolphin's presence near Ilios and Little Chopped upon three occasions, marked the only encounter in which a dolphin assumed to be a member of one extended herd interacted with dolphins from another extended herd. Pointed Finger was recorded alone 26% of the time and was observed four times with Kalypso, twice with Kinara, once with Aliki, and once with Huckleberry. Stubby, noted four times along and outside the western border of Section 6, was sighted southwest of the study area once with Kinara, and in the vicinity of five "naturally tagged" dolphins. Assuming that the largest portion of Stubby's home range lay southwest of the study area in Espiritu Santo Bay, Stubby's presence with Herd Range I dolphins may therefore have constituted an example of home range overlap and interaction with dolphins of other extended herds as was seen in the case of Pointed Finger.

Thick Fin was sighted with 10 other dolphins in the Gulf of Mexico approximately 0.5 km southwest of the Matagorda Ship Channel jetties. None of the 10 dolphins was recognized from the study area or as a "naturally tagged" dolphin which Shane (1977) and Shane and Schmidly (1978) had identified in the Aransas Pass area. The nature of Thick Fin's relationship to the herd is not known.

Mean Pod Size

Pods usually contained from two to four dolphins. Ten percent of the pods consisted of single animals. Mean pod size per month ranged from a low of 2.09 ± 0.96 (± values equal 1 SD about the mean) in January to a high of 3.32 ± 1.94 during both June and July. The slightly lower fall and winter monthly pod sizes were reflected in fall and winter seasonal pod means of 2.59 ± 1.55 and 2.54 ± 1.45 and in spring and summer pods of 3.16 ± 1.64 and 3.30 ± 1.76. Pods tended to be largest in the early morning ($\bar{X}$ = 3.02 ± 1.73) and in the early evening ($\bar{X}$ = 2.97 ± 1.66). An increase in pod size was also noted with increasing water depth. Pods varied from 2.35 ± 1.27 in water less than 0.9 m deep, to 2.92 ± 1.67 in depths of 2.7 to 4.6 m deep and 3.29 ± 1.69 in depths of 4.6 to 9.2 m. Although many of the above mean pod sizes were significantly different (Duncan's Multiple Range

Test at the 0.05 level) they represented two versus three dolphins in most cases.

A significant difference (Duncan's Multiple Range Test; $p < 0.05$) was found between pod size in open Bay Sections 1, 2, 3, and 5 and pod size in Sections 4 and 6. With the exception of Section 4, all pods in the open Bay were significantly larger than those in the constricted marshland areas and small embayments. Significant differences ($p < 0.05$) between seasonal pod sizes among the six sections were found using Duncan's Multiple Range Test. Section 4 and Section 6 fall and winter pod sizes were significantly smaller than spring and summer pod sizes in Sections 4 and 6 as well as in Sections 1 and 2. Mean pod sizes in Section 4 and Section 6 were also significantly smaller ($p < 0.05$) than mean pod sizes in Sections 1 and 2 when pod size in each section according to time of day was tested (Duncan's Multiple Range Test).

Mean pod size and standard deviation for each "natural tag" is listed in Table 10. The mean pod size for "natural tags" found in Herd Range I, composed predominantly of Sections 1, 2, and 6, was 3.22 ± 1.91. The mean pod size found for all dolphins in Sections 1, 2, and 6 as a whole was 3.17 ± 1.68. Herd Range II "natural tags" (regularly found in Sections 3 and 4) exhibited a mean pod size of 3.05 ± 1.00. Mean pod size of those two combined sections for all dolphins was 2.88 ± 1.49. The mean pod size of Herd Range III (Section 5) "natural tags" was 3.14 ± 1.59. Mean pod size for all dolphins found in Section 5 was 3.12 ± 1.88. The three "naturally tagged" Tursiops that were found near or in the Gulf (Flag, Kalymnos, and Thick Fin) exhibited mean pod sizes of 6.5 ± 2.12, 8.00 ± 2.83, and 10.00 ± 3.16, respectively.

Mean Herd Size

Although an oversight in herd notation resulted in a small sample size which may not be representative, mean herd size was calculated according to several parameters. Mean herd size varied from 11.29 ± 8.52 (± values equal 1 SD about the mean) in January to 15.24 ± 7.35

TABLE 10.— Mean pod and herd sizes (including standard deviation) for each "naturally tagged" dolphin.

Name	$\bar{X}$ Pod Size	SD	N	$\bar{X}$ Herd Size	SD	N
Sea Wolf	3.00	1.31	3	8.00	1.00	2
Kinara	3.79	2.63	34	11.67	4.63	16
Kalypso	3.65	2.22	24	11.91	8.76	11
Gash	3.50	1.79	10	15.00	5.02	6
Ourania	3.43	1.73	7	10.00	1.16	3
Flag	6.50	2.12	2	23.50	2.83	2
Kalymnos	8.00	—	1	27.00	—	1
Pointed Finger	2.89	1.73	19	15.57	7.10	8
Little Chopped	2.89	1.45	9	14.32	4.99	7
Ilios	3.20	0.55	5	14.50	4.95	3
Aliki	3.06	1.50	18	14.33	4.60	9
Antimos	2.67	1.03	6	8.01	3.54	2
Ragamuffin	3.00	2.43	7	13.00	3.54	3
Tal	2.63	1.93	8	11.00	4.24	3
Stubby	3.75	2.08	4	11.67	1.53	3
Gil	3.29	2.56	7	11.00	1.73	4
Huckleberry	3.40	1.92	5	9.33	2.83	3
Echo	3.00	1.15	2	8.00	—	1
Thick Fin	10.00	—	1	10.00	—	1
Xenon	3.00	—	1	—	—	—

in August. The slight monthly increase in herd size was illustrated more clearly in the mean herd size according to season which increased from 11.49 ± 3.21 and 12.28 ± 4.75 in the fall and winter to 13.91 ± 4.78 and 14.58 ± 6.64 in the spring and summer. Herd sizes were largest early in the morning (13.42 ± 5.75) and early in the evening (13.74 ± 2.36). Mean herd size increased as depth increased (< 9 m, 10.7 ± 2.66; > 9m, 14.84 ± 1.49). Herd sizes did not differ significantly according to month, season, or depth (Duncan's Multiple Range Test; $p < 0.05$). However, a significant difference (Mann-Whitney U Test; $p < 0.05$) was found between herds recorded in the open waters of Section 2, and herds found in Section 6. Mean herd size in Section 6 was larger than herd sizes in Sections 4 and 5, although this difference was not significant.

A significant relationship ($p < 0.05$) was found between herd size and time of day and herd size and behavior (Duncan's Multiple Range Test). Largest herds were found during Time I (0600 - 1000) and during Time IV (1700 - 2100); they differed significantly ($p < 0.05$) from herd sizes which were recorded between 1000 - 1300 and 1300 - 1700. Herds engaged in play and in shrimp boat-associated behavior were also significantly larger ($p < 0.05$) than traveling, feeding and mating groups.

Female-Calf Pairs

Calves comprised 7.21% of the total dolphin count during the year-long study. Many of the 522 sightings of female-calf pairs consisted of newborn dolphins that were easily identifiable due to their extremely small size, black appearance, vivid fetal folds, and their awkward, uncoordinated respiration. Older calves, believed to be less than 1 year old, were identified by their less than 1.7 m length (Ridgway, 1968) and their close physical contact with larger animals presumed to be their mothers.

Calves composed 8.91% of the total dolphin count in the spring, and was lowest during the fall (6.29%). When calf percentages are broken down by month, lowest figures were recorded in October and December (5.23% and 5.07%, respectively), and highest calf percentages were observed in April and June (9.09% and 9.21%, respectively). Several newborn calves were sighted in January 1979 when calves composed 8.60% of the population. Figure 31 provides a more detailed breakdown of calf percentages by month and season.

Although calves were noted throughout the study area, the highest female-calf counts were consistently recorded in Section 6, the area primarily composed of relatively protected deep channels and extensive shallow areas adjoining the channels and flats. Over the year, 39% of all female-calf pair sightings occurred within Section 6. During the fall and winter, 29% and 63% of all female-calf pair sightings were recorded in Section 6, whereas 44% and 27% were recorded there during the spring and summer. A breakdown of mother-calf pair/month and season by area is presented in Table 11. Table 12 lists the number of times and percentage of time each "naturally tagged" Tursiops was seen in the same pod or herd as one or more calves.

Only two of the "natural tags", Gash and Ourania, were known to have been mothers during the year of the study. Gash was observed with her calf during all 10 sightings, and with at least a second female-calf pair in the same pod 40% of the time. On 16 and 18 September 1978, Gash, her calf, a second mother-calf pair, and a fifth dolphin, were seen traveling towards Pass Cavallo. Following a 6-month interval in which Gash and her calf were not seen, they were subsequently sighted at the mouth of Saluria Bayou with 20 other Tursiops on 3, 4, and 5 March 1979. On 3 March, Gash was seen without her calf for brief periods of time and possibly joined one of the mating pods for several minutes. However, she was usually observed next to her calf, a second female-calf pair, and a fifth identifiable dolphin. On 26 March, Gash and her calf were again observed with a large herd of 20 to 35 Tursiops near the Port O'Connor jetties. Six days later, they were noted traveling northeast with a herd of 30 dolphins from Fisherman's Cut to the Port O'Connor jetties. Gash and her calf traveled in a pod with two other mother-calf pairs, and two or three other calves were noted within the herd. Two months later in June, Gash, her calf, and a third dolphin were sighted alone, traveling southwest in Matagorda Bay, north of the study area.

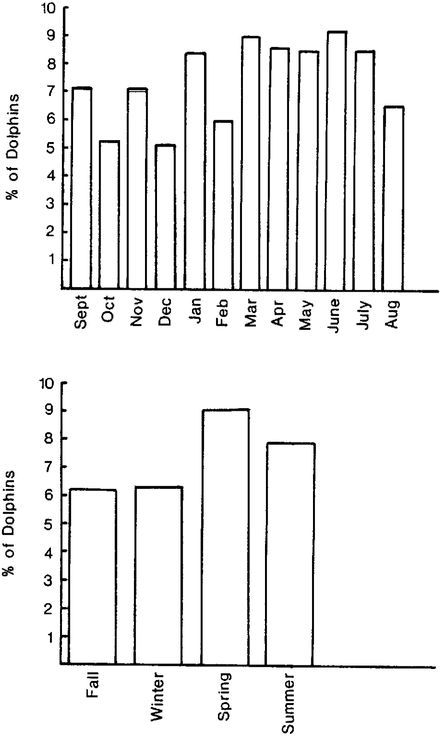


Fig. 31.— Monthly and seasonal percentages of calf sightings (as a percentage of total number of *Tursiops* sighted).

TABLE 11.— Mother-calf pairs/month and season by section.

Month	Section 1	2	3	4	5	6	Shrimping; Gulf; Espiritu Santo Bay	Total
September	5	3	2	8	8	22	3	51
October	9	5	6	13	1	11	8	53
November	4	2	10	11	2	13	11	53
December	0	5	1	4	1	13	0	24
January	0	13	2	3	0	14	0	32
February	0	2	3	2	1	35	0	43
March	18	4	1	0	1	44	14	74
April	1	5	0	0	0	14	6	34
May	9	14	4	1	0	5	1	34
June	8	4	5	0	5	13	8	43
July	13	9	1	0	7	11	2	43
August	9	1	6	2	9	10	1	38
	76	67	41	44	35	205	54	522
%	14.6	12.8	7.85	8.4	6.7	39.3	10.3	
Fall	18	10	18	32	11	46	22	157
%	11.5	6.4	11.5	20.4	7.0	29.3	14.0	
Winter	0	20	6	9	2	62	0	99
%	0	2.0	6.1	9.1	2.1	62.6	0	
Spring	28	23	5	1	1	63	21	142
%	19.7	16.2	3.5	0.7	0.7	44.4	14.8	
Summer	30	14	12	2	21	34	11	124
%	24.2	11.3	9.7	1.6	16.9	27.4	8.8	

TABLE 12.— Total number of times each "naturally tagged" Tursiops was sighted with one or more calves.

Name	Total No. Sightings	Pod	Herd	Total No. and % of Time Seen With Calf in Pod or Herd or Both Pod and Herd Simultaneously
Sea Wolf	3	1—50%	1—50%	2—67%
Kinara	34	5—24%	16—76%	21—56%
Kalypso	24	4—33%	11—92%	12—50%
Gash	10	10-100%	6—60%	10—100%
Ourania	7	6-100%	2—33%	6—86%
Flag	2	0—0%	2-100%	2—100%
Kalymnos	1	0—0%	2-100%	1—100%
Pointed Finger	19	1—13%	7—88%	8—42%
Little Chopped	9	9-100%	—	9—100% (With presumed mother)
		5—56%	4—44%	9—100% (With other calves)
Ilios	5	0—0%	3-100%	3—60%
Aliki	18	2—29%	5—71%	7—39%
Antimos	6	1—33%	3-100%	3—50%
Ragamuffin	7	0—0%	3-100%	3—43%
Tal	8	2—50%	2—50%	4—50%
Stubby	4	1—25%	3—75%	4—100%
Gil	7	2-100%	1—50%	2—29%
Huckleberry	5	2-100%	1—50%	2—40%
Echo	2	0—0%	0—0%	0—0%
Thick Fin	1	0—0%	1-100%	1—100%
Xenon	1	0—0%	0—0%	0—0%

Ourania was observed with a small calf during the fall and winter. On 2 November, she and her calf were noted following a shrimp boat, keeping some distance away from the three other Tursiops that were also following the boat. Ourania and her calf then joined a pod of five dolphins that were randomly moving several meters away but immediately moved away from the pod when they began to mate. Although Ourania and her calf remained in the vicinity, they did not approach again until the dolphins ceased to mate several minutes later. Ourania was seen with her calf and 10 other Tursiops on 26 February, but was sighted the following week without her calf. She was also seen without a calf during the next sighting on 25 June, although a calf was noted in the vicinity. However, the following day she was sighted in a pod of four adults 10 to 15 m from a second pod which included three calves. Several minutes later the two pods mingled, and Ourania was seen in the presence of a calf. She and the calf approached a shrimp boat together and began following the boat for the next hour. It is not known if this was the same calf seen during the previous encounters.

Little Chopped, a calf at least one year old, frequently left its mother's side and also approached the observation platform many times. On 19 December, after Little Chopped approached the bow of the observation platform, a larger animal immediately appeared near the boat and emitted a series of loud, expulsive breaths or snorts. Three weeks later, on 10 January 1979, Little Chopped was observed with an animal presumed to be its mother, and a newborn calf. The newborn calf was also noted 2 days later with Little Chopped and the female; however, by 22 January, only Little Chopped and the presumed mother were observed together. On 28 February, Little Chopped, the presumed mother, and a second female-calf pair were observed traveling together.

Most evident among the similarities with respect to Ourania Gash, Little Chopped, and other mother-calf pairs was the degree of segregation which was maintained. Female-calf pairs were often sighted traveling completely alone or in the company of a third dolphin or a second female-calf pair. Within herds, female-calf pairs were also either alone or in the company of one or two other female-calf pairs. Newborn calves, noted close to their mothers and often flanked by a second adult, stayed some distance away from other _Tursiops_, especially when traveling and when following trawling shrimp boats. Calves were never observed within mating pods, and deliberate movement away from such pods was, in fact, observed. When herds were followed, older calves frequently approached the observation platform in the company of other large calves or juveniles without their mothers. Groups of older calves within large herds were also observed leaping and playing together. It is not known if female-calf pairs tended to range over larger distances than did other _Tursiops_, although Gash and her calf were found over widely-separated areas.

Herd Composition

Large herds were composed of variously-sized animals, with notable segregation within the larger unit. Pods of female-calf pairs, female-calf pairs plus one or two larger animals, juveniles, and large animals constituted the entire herd unit.

Dolphin - Shrimp Fishery Association

Published accounts of food and feeding behavior by True (1885), Townsend (1914a), Gunter (1938, 1942, 1951, 1954), Harris (1938), Kemp (1949), Golley (1966), Hoese (1971), Caldwell and Caldwell (1972a), Leatherwood (1975), Shane (1977), and Shane and Schmidly (1978) depict _Tursiops_ as being flexible in its feeding habits and easily adaptable to the most abundant and available fish at the time. That _Tursiops_ is both catholic in its feeding regime and adept at exploiting an easy food source was illustrated in the dolphins' shrimp boat-associated feeding patterns. Initially considered a small, insignificant aspect of their feeding repertoire, it became apparent that the dolphins' attraction to shrimp boats not only influenced feeding ecology, group composition, social behavior, and interspecific interactions, but also posed many questions regarding activity cycles and seasonal movements.

Shrimping is exclusively a bottom trawl fishery (Moffett, 1974).

Dolphins have exploited the shrimping operation due to the fact that for every pound of shrimp, eight to as many as 20 pounds of unwanted fish and other organisms are incidentally captured and later discarded (Fig. 32A). A wide range of species including Atlantic croaker (Micropogon undulatus), spotted seatrout (Cynoscion nebulosus), sand trout (Cynoscion arenarius), sheepshead (Archosargus probatocephalus), flounder (Paralichthys), ribbon fish (Trichiurus lepturus), gafftop (Bagre marinus), hardhead (Arius felis), Atlantic stingray (Dasyatis sabina), striped burrfish (Chilomycterus schoepfi), and angelfish (Chaetodipterus faber) are commonly caught (Fig. 32B). Organisms not captured in the net are stirred up by the pressure of the otter doors and net as they are towed along the sea floor. Therefore, dolphins may frequently be seen several meters behind the boat, often in the vicinity of the cod-end of the net, presumably picking gilled fishes out of the net as well as feeding on stirred-up fishes and organisms along the bottom (Figs. 33A and 33B). When the catch is dumped onboard, the incidentally-caught trash fish are culled out from the more valuable shrimp and then thrown overboard, usually wounded, dead, or dying. Dolphins also closely approach the boats in order to take trash fish as they are discarded (Figs. 33C and 33D) in addition to following the net as it is towed.

Major Stages of Operation

Five major stages of the shrimp fishery operation were recognized as follows: (1) the docked or anchored non-working shrimp boat, (2) underway to or from the shrimping grounds, (3) towing the trawl, (4) towing the trawl and simultaneously culling out, and (5) idling, drifting, or anchored in the Bay or Gulf and culling out.

Docked or Anchored Non-Working Shrimp Boats. Dolphins were observed milling around docked shrimp boats upon 53 occasions. Mean pod size during these instances was 2.2 ± 1.34 ($\pm$ values equal 1 SD about the mean). In some cases, the dolphins were moving through the adjacent Intracoastal Waterway and veered off into the boat slips, milled around the boats, randomly dived, and possibly fed. Herds traveling past the shrimp boat docks generally followed their original course,

A

B

Fig. 32.— (A) The trawler knot is untied after the "bag" is hoisted aboard the "Capt. Morocco". Note the predominance of fish entangled in the net mesh. (B) A typical "drag" including hard head (Arius felis), trout (Cynoscion), Atlantic stingray (Dasyatis sabina), croaker (Micropogon undulatus), and spot (Leiostomus xanthurus).

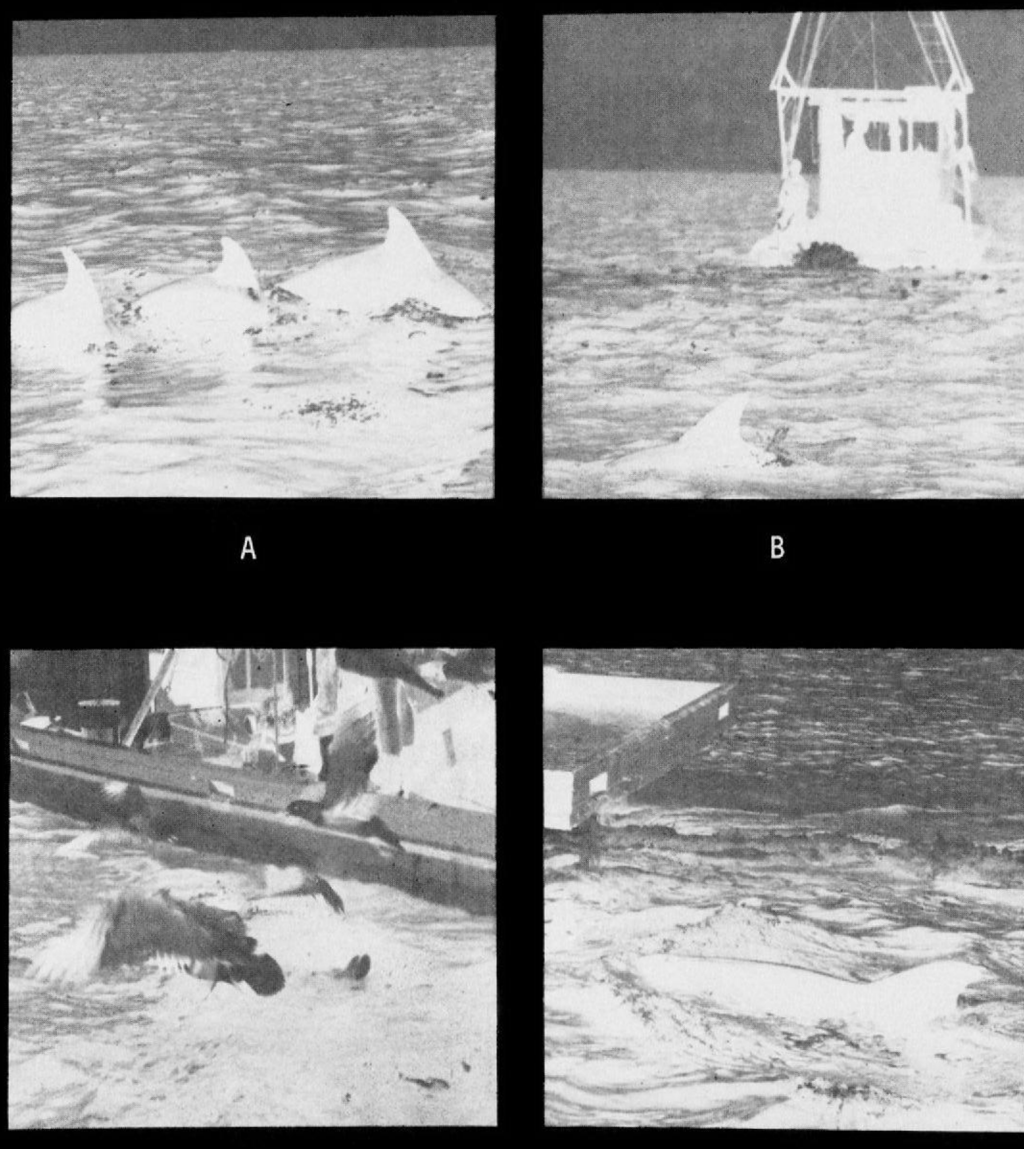


Fig. 33.— (A) Three Tursiops follow a working shrimp boat in a uniform manner, presumably feeding upon gilled and stirred-up fish and organisms. (B) A dolphin moves sideways along the width of a trawl being towed off the Matagorda Peninsula. (C) One dolphin daintily picks a fish from the surface as the "Mary R" drifts during culling out. (D) A dolphin follows close to the stern of the "Mary R" while feeding on discarded trash fish.

although some individuals would meander around the boats before rejoining the herd.

Dolphins were noted milling around anchored shrimp boats in Matagorda Bay near the Matagorda Ship Channel jetties several times as the boats waited to continue into the Gulf of Mexico later in the day.

Underway To or From Shrimping Grounds. Dolphins often rode the bow-waves of shrimp boats underway to or returning from shrimping grounds at relatively high rates of speed (Fig. 34A) Dolphins usually approached by performing racing-dives (series of rapid surfacings exposing much of the dolphin's dorsal surface). Mean pod size of dolphins riding the bow-waves was 3.00 ± 1.97.

Dolphins were followed upon eight occasions after the last catch was boated and the shrimper headed towards town. In two instances, they remained in the area and began randomly moving and feeding and occasionally nuzzling one another. Upon another occasion, a herd of 15 *Tursiops* split into two distinct pods which continued to feed for several minutes, and then, still separate, moved towards shore and began to mate. During the other instances, dolphins followed the departing shrimp boats for several seconds, abruptly ceased to follow, and began to mill around.

Towing the Trawl. Dolphins were observed racing-diving towards shrimp boats when the net was initially put over. Other times they were already following the trawls when initially sighted. Dolphins traveling in a definite, goal-oriented manner were followed as they abruptly changed direction in order to approach a shrimp boat. Upon still other occasions, dolphins engaged in random movement, mating, or play behavior, would suddenly approach and begin to follow shrimp boats which had been working in the vicinity for several hours. During towing, the dolphins followed several meters behind the boat, most often in the vicinity of the cod-end of the trawl, and sometimes near the mouth of the net. They would also move up and down or across the net in pods averaging 2.86 ± 1.57 (Fig. 33B). Three to 10 *Tursiops*/boat moving in intermingling pods of two to four animals were most commonly observed.

During towing, a minimum of the dolphins' time was spent in close

A

B

C

Fig. 34.— (A) A single dolphin rides the bow-wave of "Little Sister" as she travels out the Port O'Connor jetties towards Matagorda Bay. (B) Two dolphins follow the trawl forward as it is winched towards the stern of the "Mary R". (C) One dolphin remains in the vicinity of the "bag" before it is hoisted aboard the "Mary R".

proximity to the shrimp boat, since they tended to associate near the net, several meters behind the stern. When the trawl was "picked up", the dolphins would follow it up to the stern (Figs. 34B and 34C) and would usually mill around the sides or bow of the boat while the "bag" was hoisted aboard, the catch dumped out on deck, and the trawler knot retied (Figs. 35A and 35B). The mean pod size of 4.39 ± 1.36 during this portion of the procedure was larger than that of any other shrimp boat-related activity due to the dolphins' habit of converging upon the net from several directions as it was slowly hauled towards the boat. As the trawl was put over again, the dolphins would return near the stern and immediately begin to follow the trawl away from the boat. They would then turn about-face and racing-dive towards the boat in order to keep up with it as it temporarily increased speed to insure that the cable and trawl entered the water untangled. When the boat's speed decreased and normal towing resumed, the dolphins once more began to follow the net in smaller pods ($\bar{X}$ = 2.79 ± 1.59).

Simultaneously Towing the Trawl and Culling Out. During periods of simultaneous towing the trawl and culling out trash fish, dolphins still appeared to prefer following several meters back from the stern in the vicinity of the mouth and cod-end of the net and did not closely approach the shrimp boat until the net was hauled onto the deck once more. In only one instance were dolphins ever observed up at the stern feeding on discarded trash fish while the net was simultaneously being towed (Fig. 36A and 36B).

Idling, Drifting, or Anchored and Culling Out. Dolphins approached shrimp boats closely during culling out when the boat did not tow a net, but rather drifted, idled, or was anchored in the Bay. They would approach directly up to the stern or sides of the shrimp boat while feeding on discarded trash fish. Shrimpers sometimes hand-fed dolphins as the animals crowded close to the shrimper and raised their bodies halfway out of the water, bobbing up and down.

In order to conserve both time and fuel, many bay shrimpers work 2 to 4 days in the bays or Gulf before returning to the docks to unload their catches. After the last tow of the day, they either tie up to an oil platform or anchor the boat, and then finish culling

A

B

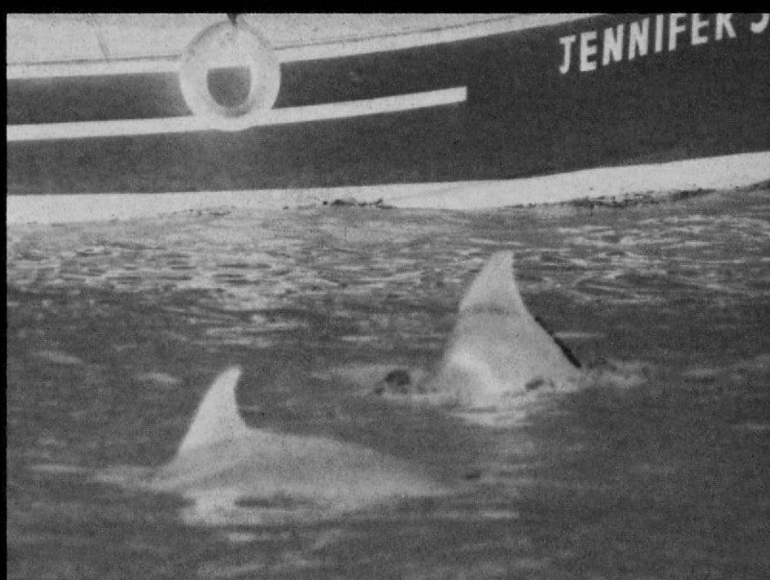


Fig. 35.— (A) Two Tursiops move away from the trawl and stern of the "Mary R" towards the starboard side and bow of the boat as the "bag" is hoisted aboard. (B) Thick Fin and a second dolphin randomly move about near the bow of the "Jennifer Sue" while the catch is hoisted aboard, dumped on deck, and the trawler knot is retied.

A

B

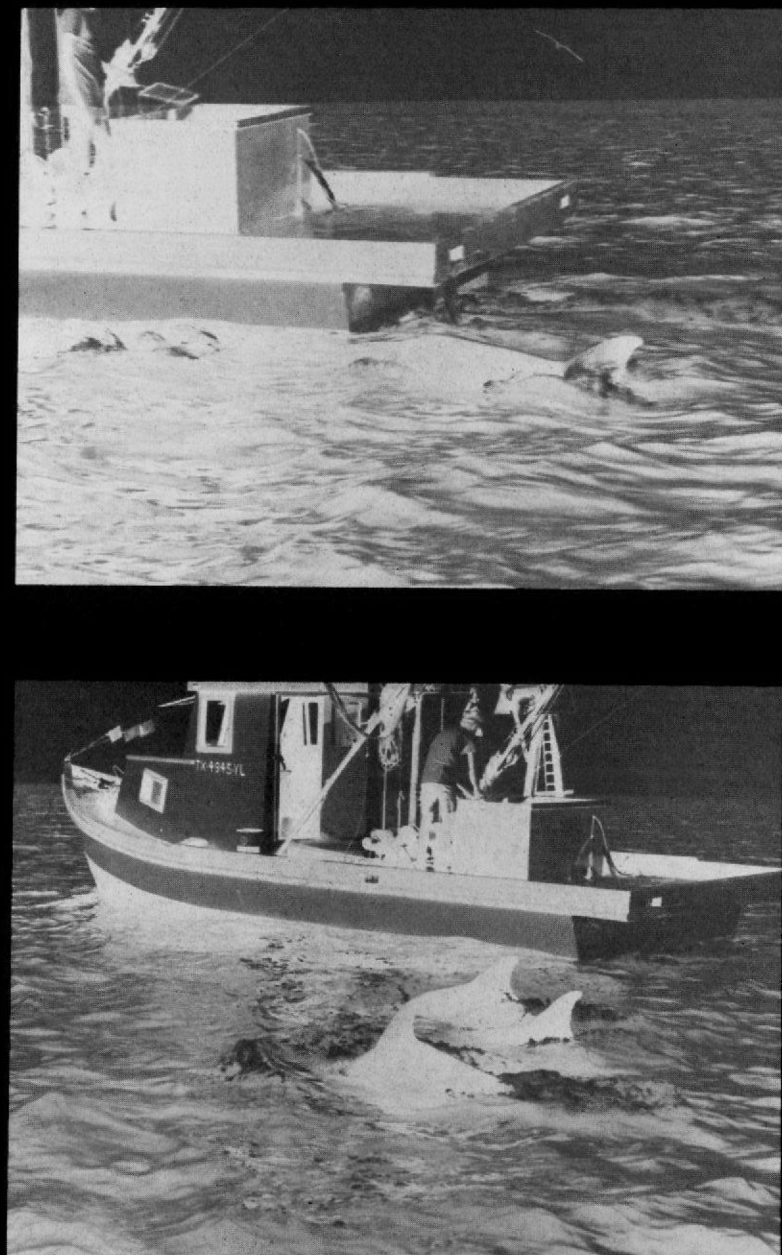


Fig. 36.— (A) Two dolphins feed at the stern of the "Mary R" during towing and simultaneous culling out. Large air bubbles well up to the surface at the port side of the boat. (B) Three dolphins feed on discarded trash fish during towing and simultaneous culling out.

out the last tow. Some of the largest concentrations of *Tursiops* around shrimp boats were recorded during these periods as 15 to 25 dolphins would completely surround the boat and continuously dive after cull for several hours.

"Naturally Tagged" Dolphins and Shrimp Boats

Nine of the 20 "naturally tagged" dolphins were observed associating with shrimp boats in some way. Sea Wolf followed shrimp boats in the Matagorda Ship Channel during all three sightings. Ourania was observed following shrimp boats five of the seven times that she was sighted. The single sighting of Xenon occurred as the dolphin followed 25 m behind a trawling shrimp boat. Pointed Finger and Ilios were each noted feeding on discarded trash fish near the stern of a small shrimper in the Matagorda Ship Channel. Little Chopped was sighted 11 km north of the Peninsula bulkhead following a shrimp boat, and Ragamuffin was observed following a shrimper in the middle of Section 2. Thick Fin was sighted in the Gulf of Mexico feeding and milling around several boats. On 14 March 1979, when the investigator was aboard the "Capt. Morocco", Aliki rode her bow-wave from the Port O'Connor jetties west in the Intracoastal Waterway to Clark's Fish House, where the boat slowed down. Huckleberry was noted riding the bow-wave of the Gulf shrimper "Jet Star" on 9 June 1979 as the vessel traveled east towards the Matagorda Ship Channel jetties. With the exception of the April sightings of Little Chopped, all other sightings of "natural tags" and shrimp boats occurred in the general areas where they had been previously recorded.

Seasonal Movements

Virtually no bay shrimping occurs in Matagorda Bay during the winter except for a limited amount of bait shrimping in the Ship Channel. During the winter of 1979, an increase of dolphins in the deep back channels of the study area was noted, and extensive movements back and forth from Pass Cavallo through Saluria Bayou and into the shallow back embayments and Espiritu Santo Bay were recorded. A slight decline of dolphins in the open Bay sections was seen with the exception of the portions of Section 2 closest to the Ship Channel jetties and Pass Cavallo, and the grids in Pass Cavallo adjacent to Saluria Bayou. A more dramatic decline was noted in the spring when relatively few dolphins were found throughout the entire study area. Shrimpers, however, reported high numbers of Tursiops 8 to 10 km north of the study area. These reports were confirmed during several days of observations in April, May, and early June when 50 to 75 dolphins were regularly seen associating with shrimp boats. It was during one of these encounters that Little Chopped was sighted 9 km north of Section 4 on 25 April 1979. Fifteen shrimp boats and 67 dolphins were counted.

Section 5 and the portion of the Matagorda Ship Channel adjacent to it were virtually empty of dolphins during much of the winter and spring. By late spring, and especially during the summer and early fall, a dramatic increase of dolphins that coincided with the section's heavy use by shrimpers was evident. Nearly all animals observed were associating with shrimp boats in some way, whether by actively following and feeding, or by mating, playing and randomly moving to the side of the boats. Estimated density in Section 5 increased from 0.238 ± 0.22 Tursiops/km^2 in May to 1.05 ± 0.29 Tursiops/km^2 in August (from 5.33 to 23.53 dolphins, respectively). Similarly high numbers were recorded during the previous summer's pilot study. Numbers remained high until the end of September and beginning of October when shrimpers shifted from Section 5 near the mouth of Powderhorn Lake to the Section 4 area along and north of the Peninsula near the bulkhead. Section 5 density dropped from an estimated 0.702 ± 0.42 Tursiops/km^2 in September to 0.186 ± 0.20 Tursiops/km^2 in October.

Activity Cycles

Predominant activities during the morning appeared to consist of following the net and feeding. Mating was noted during the late morning and in the afternoon, usually after several hours of uninterrupted feeding. Following the net in a less regimented fashion was seen in the afternoon, and dolphins often hung far back from the net and erratically moved from boat to boat, mated for several minutes, haphazardly followed a boat again, switched boats, and then mated again. Recognizable pods of dolphins often remained in the same area throughout much of the day, sometimes completely off to the side of the mass of boats trawling back and forth and in circles in small selected areas of the Bay. Identifiable dolphins were sighted following shrimp boats within the same area on consecutive days, and, as previously mentioned, late night feeding around anchored boats in the Bay and Gulf was quite common.

Social Composition and Behavior

Mean pod size ranged from 2.22 ± 1.19 in the fall to 3.33 ± 1.87 in the spring of 1979. Herd sizes rarely exceeded eight to 10 dolphins, although during April and July 1979, 10 to 15 dolphins per boat were regularly noted. During early August, 15 to 25 Tursiops were observed behind each of the three or four boats that were shrimping in Sections 3 and 5. Herds consisting of female-calf pairs, juveniles, and large animals were segregated at variously-spaced intervals at least 20 to 50 m behind the stern toward the cod-end of the trawl and along its width. Dolphins that were briefly sighted alone also associated with other animals in pods that constantly restructured.

Although female-calf pairs were seen following shrimp boats, it was not determined whether any of the calves were actively feeding. During April 1979, several newborn calves that were flanked by an adult on either side were observed in herds that were following working boats.

Pods and herds intermingled when animals that had just entered the general area approached a boat which other dolphins were already following, or when dolphins ceased to follow one shrimp boat and switched to another boat which several dolphins were already following. Switching occurred when a boat being followed left the area and a new boat was approached; or when dolphins began to follow a new boat rather than wait for the initial boat's net to be hauled in, emptied, and put over again; or when dolphins mated and played and haphazardly moved back and forth among several boats. Dolphins that had switched from one boat to a second boat often encountered pods already following the second boat. In some cases, a brief separation existed between the two pods, after which all animals would mingle. Other times, all animals immediately interacted with one another. Agonistic displays by dolphins already following a boat were never observed towards dolphins that had joined them.

Mating and playing were frequent occurrences around the shrimp boats, although interactions of these sorts appeared to be most prevalent following several hours of feeding. During other occasions, the usual short- and long-dive patterns were interspersed with much collective aerial behavior as dolphins leaped simultaneously, nuzzled one another, racing-dove, and tail-slapped.

Gulf Shrimping

Dolphins were observed following shrimp boats in the Gulf (2 to 5 km offshore) twice from the "Capt. Morocco", and three times from the project boat. Mean pod size (3.81 ± 1.91) was larger than was observed in the Bay; herd sizes, averaging 12 to 15 dolphins per boat, were also larger. Active and vigorous surface and aerial behavior including frequent leaps, racing-dives, and tail-slaps were recorded more often in the Gulf than in the bays.

On 22 March 1979, four _Tursiops_ followed several meters behind the "Capt. Morocco" for 2 hours. The trawl was "picked up" at nearly 1800 h, at which time the dolphins immediately departed. The trawl was completely empty and apparently had been adjusted incorrectly when it initially entered the water. No fish or shrimp had been taken during the entire 2-hour period. Even so, the dolphins had apparently continued to feed on the large quantities of fish and organisms which were stirred up as the net passed along the Gulf floor.

Shrimper Questionnaire

A good rapport was maintained with area shrimpers who offered their assistance whenever possible. Informal discussions about dolphins and shrimping included candid descriptions of dolphins accidentally captured in the trawl, hand-feeding dolphins, shooting to scare away or kill dolphins in retaliation for supposed damage to nets, and "fishing" for dolphins using hook, bait, and line. Generally speaking, however, most shrimpers seemed quite fond of the dolphins and were interested in learning more about them.

A questionnaire was distributed to approximately 50 local shrimpers in order to gather more detailed information concerning the type and extent of contact between dolphins and shrimpers, an area of great concern when taking the practical aspects of the Marine Mammal Protection Act into account. Fourteen of the 23 completed questionnaires were done so by personal interview. The questionnaire may be found in Appendix A.

It is recognized that the interviewed shrimpers could offer little more than conjecture regarding many of the questions, particularly those involving dolphin daily and seasonal movements and the influence that shrimping has upon them. However, shrimpers, as a group, come into close contact with dolphins more often than any other group of humans along the Texas coast. Therefore, it was considered extremely important to become aware of, and thoroughly familiar with, their ideas, attitudes, and observations about dolphins and shrimping, no matter how speculative or anecdotal.

The majority of shrimpers stated that the dolphins' constant presence around the boats did not constitute a nuisance to them. They appeared, in fact, rather fond of the animals although there was much disagreement regarding the dolphins' questionable responsibility for damage to shrimp trawls. Fifty-nine percent of the shrimpers claimed that dolphins damaged their trawls, while 23% replied they did no damage, and 18% did not know. Many shrimpers maintained that "crow's feet" (small, triangular three-to-four-mesh-sized holes) which were easily distinguishable from the large rips caused by sharks, were the result of dolphins yanking gilled fish from the net. Other shrimpers claimed that jack fish (Caranx hippos) tore "crow's feet" and dolphins daintily plucked the fish from the trawl, causing no damage. Widespread trawl damage blamed on dolphins was claimed to occur prior to 1961 when the trawls were constructed of cotton. Shrimpers commonly shot dolphins until they began to use trawls constructed of a nylon-cotton mix (ny-cot) in the early and middle 1960's. A dramatic decline in damage was supposedly noted.

Mullet (Mugil cephalus) may comprise a large portion of the diet of Tursiops when feeding under natural conditions (Gunter, 1942; Kemp, 1949), but bottlenosed dolphins appeared to prefer ribbonfish (Trichiurus lepturus), sand trout (Cynoscion arenarius), whiting (Menticirrhus littoralis), and croaker (Micropogon undulatus) over mullet when faced with a choice of several species from shrimp boats. Additional information of an anecdotal nature was obtained from several shrimpers who, aware of dolphins' supposed predisposition towards mullet, hand-fed them from a variety of species including mullet, ribbonfish, trout, whiting, and flounder. Three shrimpers from three different boats during various months of the year stated that none of the dolphins would accept any mullet. However, they seemed most fond of ribbonfish, followed by trout, whiting, croaker, and flounder (D. Walker, pers. comm.)

Strandings

The year-long study was well-publicized in Port O'Connor, and, to a lesser extent, in the neighboring towns of Seadrift and Indianola. Posters were distributed throughout the three towns as well as in Port Lavaca, 25 km northwest of Port O'Connor. A total of 23 stranded cetaceans were recorded. Fourteen of them were photographed and measured, and eight of those were also necropsied. The remaining nine cetaceans were not seen primarily due to their inaccessibility.

Table 13 provides a breakdown of stranding information, including reporter, date observed and/or worked, location, species, number of individuals, sex, length, condition, and possible cause of death.

TABLE 13.— Data on stranded cetaceans reported from June 1978 until August 1979.

Reporter	Date	Location	Species	No.	Sex	Length (cm)	Condition	Remarks; Cause of Death
David Walker, Pt. O'Connor	6/15/78	SW shore, Pass Cavallo	_T. truncatus_	1	?	213.36	Dead 2 mos. or more; skin leathery, skeleton exposed	?
Gruber	6/24/78	N shore of Intracoastal Waterway/ Army Cut	_T. truncatus_	1	?	193.04	Dead 5-7 days; chewed up around genital area, caudal peduncle	?
Petroleum Helicopters, Inc.	8/1/78	3 km NW Indianola Harbor	_T. truncatus_	1	M	304.80	Dead 1-2 days; bloody but no gross cuts or mutilations	Seen immed. after Tropical Storm Amelia
Houston Radio	12/21/78	U.S.C.G. Station, Pt. Isabel, Tex.	_T. truncatus_	1	M	243.84	Dead 8-9 days; several harpoon wounds near blowhole	Harpooned near ends ville Ship Channel jetties by Mexican fishing vessel
Houston Radio	12/21/78	"	_S. plagiodon_	1	M	217.17	"	Harpooned several km offshore Pt. Isabel
Houston Radio	12/21/78	"	_S. plagiodon_	1	F	209.55	"	"
Houston Radio	12/21/78	"	_S. plagiodon_	1	?	?	"	"
Steve Knode, Aransas Wildlife Refuge, Matagorda Is.	1/8/79	Matagorda Is. Gulf Beach, 9 km SW Pass Cavallo	_Mesoplodon densirostris_	1	F	396.24	Dead 1 day; lg. open wound exposing intestines, ribs	?

TABLE 13 (Continued).

Reporter	Date	Location	Species	No.	Sex	Length (cm)	Condition	Remarks; Cause of Death
Chuck Williams, Pt. O'Connor	1/15/79	SW Big Bayou	*T. truncatus*	1	?	?	Not observed	?
Jimmy Shelton, Aransas Wild-life Refuge, Matagorda Is.	2/19/79	Matagorda Is. Gulf Beach; 20 km SW Pass Cavallo	*T. truncatus*	1	M	204.47	Dead 2-3 days; part of skull exposed; notice-ably emaciated around neck	No food in stom-ach
Gruber	2/27/79	Intracoastal Waterway/ Army Cut	*T. truncatus*	1	M	187.96	Dead 2-3 days; deep boat prop scars on ven-tral surface	Intestines, colon torn and ripped; necrop-sied at TAMU Sch. Vet. Med.
Gruber	3/3/79	Matagorda Peninsula Gulf Beach, 3 km NE Pass Cavallo	*T. truncatus*	1	F	185.42	Dead at least 2 mos.; dry and leathery; half of flukes chewed off	?
Gruber	3/3/79	Matagorda Peninsula Gulf Beach, 3.5 km NE Pass Cavallo	*T. truncatus*	1	M	117.76	Dead 2-3 days; newborn, no scars; hole at umbilicus	?
Murray Muston, Pt. O'Connor	3/13/79	N. shore Espiritu San-to Bay near Army Cut	*T. truncatus*	1	?	213.36	Dead at least 2 mos.; no append-ages; part of skeleton, skull exposed	?

TABLE 13 (Continued).

Reporter	Date	Location	Species	No.	Sex	Length (cm)	Condition	Remarks; Cause of Death
Resident, Pt. O'Connor	3/14/79	Matagorda Bay shore; 50 m NW Pt. O'Connor jetties	_T. truncatus_	1	F	115.57	Dead 1-2 days; newborn; no external injuries	?
Ed Smith, Jr., Law Enforcement, NMFS	3/15/79	St. Joseph's Is. $28^{\circ}01'$N, $97^{\circ}54'$W	_T. truncatus_ ?	1	?	182.88	?	Observed from fixed-wing sm. aircraft
Ed Smith, Jr.	3/15/79	St. Joseph's Is. $28^{\circ}03'$N, $98^{\circ}50'$W	_T. truncatus_ ?	1	?	?	Badly decomposed	"
Ed Smith, Jr.	3/15/79	45 km SW Bob Hall Pier, Padre Island	_T. truncatus_ ?	1	?	Approx. 233.68	Head removed	"
Jimmy Shelton	3/29/79	Matagorda Is. Gulf Beach, 18 km SW Pass Cavallo	_T. truncatus_	1	M	236.22	Discolored and bloated	?
Jimmy Shelton	4/15/79	Matagorda Is. Gulf Beach, 16 km SW Pass Cavallo	_T. truncatus_	1	?	114.44	Newborn	Not seen
Haynes Harte, Pilot	8/1/79	Matagorda Is. Gulf Beach, 16 km SW Pass Cavallo	_T. truncatus_	1	?	96.52	Possibly newborn	Not seen

TABLE 13 (Continued).

Reporter	Date	Location	Species	No.	Sex	Length (cm)	Condition	Remarks; Cause of Death
Shrimper, Pt. O'Connor	8/30/79	Middle Matagorda Bay	*T. truncatus*	1	?	243.84	Dead in shrimper's net	Not seen; possibly drowned in net
Nueces County Parks Dept.	8/31/79	Bob Hall Pier, Padre Island 27°34'52"N, 97°13'07"W	*Mesoplodon europaeus*	1	F	431.8	Dead 1 day; pregnant	Some tissue frozen; carcass buried; not seen

Species

Four species were represented among the strandings, including Tursiops truncatus (14), Stenella plagiodon (3), Mesoplodon densirostris (1), and Mesoplodon europaeous (1). The remaining four stranded cetaceans were reported as Tursiops truncatus but were not seen and the identifications have not been verified.

Location

Fifteen of the 23 stranded cetaceans were found within a 20-km radius of Pass Cavallo (Fig. 37). Five stranded Tursiops were found within the study area itself, and three additional Tursiops were found less than 4 km away from the study area. Seven other cetaceans were found along the Gulf beaches of Matagorda Peninsula and Matagorda Island, and, farther southwest, along St. Joseph's Island and Padre Island. Four dolphins did not actually strand, but were harpooned by a Mexican fishing vessel off South Padre Island, near the town of Port Isabel, Texas.

Seasonal Occurrence

Thirty percent of the strandings occurred during the winter and 39% occurred during the spring. No strandings were reported during the fall. During March alone, eight strandings (35%) were recorded, two of which were newborn Tursiops. A total of six animals were reported stranded during the summers of 1978 and 1979.

Sex

Eleven of the strandings were not sexed, and the remaining 12 consisted of seven males and five females. Six of the Tursiops were male and two were female. The four newborn Tursiops included one male and one female.

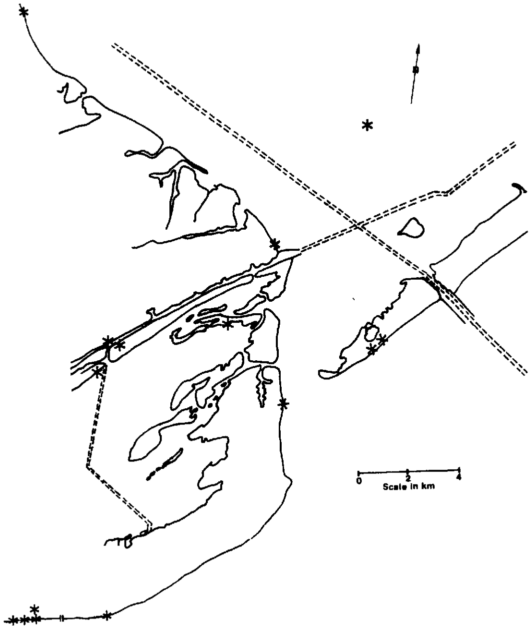


Fig. 37.— Locations of 15 cetaceans which stranded inside or within a 20-km radius of Pass Cavallo. Not included: _Stenella plagiodon_ (3); _Tursiops truncatus_ (1); _Mesoplodon europaeus_ (1); unknown (3).

Age-Size Classes

Body lengths of _Tursiops_ were used to approximate their ages. Age estimates in years were made according to Ridgway's (1968) age-size classes which are broken down as follows: less than 167.64 cm = 1 year or less; 167.64 - 198.12 cm = 1 - 3 years; 198.12 - 228.6 cm = 3 - 6 years; and over 228.6 cm = 6 years or more. The 14 _Tursiops_ represented all four age-size classes. Four of them were less than 167.64 cm long; four of them were between 167.64 and 198.12 cm long; three of them were between 198.12 and 228.6 cm long; and three of them measured over 228.6 cm.

Possible Causes of Death

Four dolphins died as a result of being harpooned, and one _Tursiops_ was badly cut and suffered severe internal injuries caused by a boat propeller. One _Tursiops_ possibly drowned in a shrimper's net, and the death of another may have been related to the unusually high tides and severe conditions of Tropical Storm Amelia. Causes of death for the 16 other strandings could not be determined.

Preservation

Four skulls (_Stenella plagiodon_, 2; _Mesoplodon densirostris_, 1; _Mesoplodon europaeus_, 1) were transferred to the Texas Cooperative Wildlife Collection of Mammals at Texas A&M University. Both stenellids and the young _Tursiops_ that was hit by a boat propeller were necropsied at the Texas A&M School of Veterinary Medicine.

DISCUSSION

Spatial and Temporal Abundances

Entire Study Area

An increase in dolphins around Pass Cavallo and the Matagorda Ship Channel jetties, through which the entire Matagorda-Lavaca Estuarine System-Gulf of Mexico exchange occurs, was noted by late October. Heavy activity along the length of the Matagorda Peninsula from Decros Point to the bulkhead was also recorded. The noticeable concentrations of dolphins near the two outlets into the Gulf may have been in response to the Gulfward movement of a diversity of fish species (Simmons and Hoese, 1959; King III, 1971; Stokes, 1977).

Estimated density within the study area increased from late October until the February peak. By March, dolphin counts declined by nearly one-third. The April estimate numbered less than half of the March total. Large concentrations of dolphins were concomitantly found less than 10 km north of the study area, suggesting the possibility of a seasonal shift towards the middle of Matagorda Bay. Dolphins which were encountered during April and May appeared unusually wary and evasive, due, perhaps, to the high percentage of newborns accompanying them. Prevailing southeasterly winds which were particularly strong during that period resulted in continuously choppy bay waters. Adverse sea state conditions coupled with the dolphins' elusive behavior and avoidance of the observation platform may have contributed to the extremely low April count. However, dolphin counts were similarly low on days of good visibility and sea states.

The slight increase in dolphin numbers noted in May continued until the end of July, although estimated numbers were substantially lower than the earlier fall and winter counts. A drop in density from July was evident in the August values and was only somewhat lower than the previous September's count.

Shane (1977) and Shane and Schmidly (1978) noted a slight decline in dolphin numbers in the Aransas Pass area from July until October; a sharp increase in numbers was recorded in November and continued until the population estimate peaked in January. A similar trend (although on a far smaller basis) was noted in the Pass Cavallo area in which the increase in estimated population size that was noticeable by the end of October peaked in February. Numbers between November and February remained stable with varying fluctuations among different study area regions. During March, April, and May, striking declines in the population estimates were recorded. Shane (1977) and Shane and Schmidly (1978) also noted a steady decline from their January high during February, March, and April. Their population then leveled off by May 1976, and was slightly higher than it had been during the previous summer when relatively stable numbers had been recorded. Stable numbers were also noted in the Pass Cavallo area during the summer of 1979, and a decline, as was seen in the Aransas Pass area, was also noted from July to August.

Shane (1977) and Shane and Schmidly (1978) stated that the abundance of dolphins in their study area varied on a monthly and seasonal basis, thus contradicting Gunter's (1942) claim of "...no evidence of migrations or seasonal abundance variations...". Shane (1977) and Schmidly and Shane (1978) stated that the variation they observed may have been due to the unusually severe winter of 1976-1977 which generated a mean water temperature of 11.4°C. The mean winter water temperature in the Pass Cavallo area in 1978-1979 registered 13.05°C, and a seasonal variation in estimated numbers was also noted.

Caldwell and Caldwell (1972a) reported heavy concentrations of dolphins in northeastern Florida during the spring and early summer. Few dolphins frequented those same areas during September and October. Hogan (1975) also noted seasonal variation in the number of <u>Tursiops</u> in his study area on the Atlantic coast. Contrary to the winter peaks observed during this study as well as by Shane (1977) and Shane and Schmidly (1978), Hogan (1975) recorded a summer population that was approximately three times the size of the estimated winter population. Although Irvine et al. (1979) also noted a decrease in dolphin abundance in their study area during the winter, they attributed the difference in numbers to poor sighting conditions, potentially different activity cycles and habitat use, or possible winter emigration. They found no evidence strong enough to state that a seasonal migration had occurred.

Six Sections

Dolphin density among the six sections varied greatly, and, contrary to Shane (1977) and Shane and Schmidly's (1978) assumption that dolphins/section related to the section's size, high estimated density was often found in small, constricted areas such as Saluria Bayou, Devil's Elbow, and the Intracoastal Waterway. Density was highest on a yearly basis in the Matagorda Ship Channel and in Pass Cavallo, while Section 4 ranked third highest, and Sections 6, 2, and 5 ranked fourth, fifth, and sixth, respectively. In other words, the two outlets into the Gulf of Mexico contained the highest yearly estimated dolphin densities, followed by the Bay shoreline (Section 4), the productive marshlands (Section 6), and, finally, the open bay areas of Sections 2 and 5. High concentrations similar to those observed in Section 4 were also apparent in near-shore Grids 21 to 26 of Section 2. These higher near-shore values of Section 2 were dampened by its larger square area nearly three times that of Section 4.

Sections by Month and Season

Gunter (1942) stated that in Texas, bottlenosed dolphins concentrated around the passes during the winter. Irvine et al. (1979) also observed large numbers of dolphins in the vicinity of Florida passes during the winter. High winter counts were observed in Pass Cavallo, particularly in the lower reaches of the Pass, off the tips of Matagorda Island and Matagorda Peninsula, in and adjacent to the breakers along the shoaling middlegrounds of the Pass, and farther northwest at the point of intersection of Pass Cavallo and Saluria Bayou where the tidal flow was especially pronounced. Large concentrations of dolphins were also recorded 2 km to the northwest at the mouth of Big Bayou. Shane (1977) and Shane and Schmidly (1978) found that dolphins were most abundant in Aransas Pass during November, although estimated numbers were also quite high there during January and June. Estimated density in Pass Cavallo declined slightly during February and March, and more radically in April, the month during which low numbers of dolphins were recorded throughout the study area. Estimated density in the Pass from May until August was identical to the trend seen throughout the entire study area and generally increased from May until July and declined from July until August.

The Matagorda Ship Channel exhibited an abundance of dolphins, particularly in Grids 31 and 32 during October and November. The concentration of dolphins in those grids and near the Gulf that occurred with the onset of cooler weather may have been related to the emigration of many species of fishes from the shallow bays to the deeper, warmer Gulf waters. Simmons and Hoese (1959) reported heavy emigration of southern flounder (*Paralichthys lethostigma*) through the Cedar Bayou outlet from September through December 1950, and Stokes (1977) stated that sexually mature *Paralichthys* left the Aransas Bay area of Texas during October, November, and December 1974-1975 for spawning in the Gulf of Mexico. Simmons and Hoese (1959) also noted movement of spotted seatrout (*Cynoscion nebulosus*) into the Gulf of Mexico from September through December 1950. Atlantic croaker (*Micropogon undulatus*), sand trout (*Cynoscion arenarius*), striped mullet (*Mugil cephalus*), and redfish (*Sciaenops ocellata*) move from the shallow bays to the Gulf during the fall (Hoese and Moore, 1977). The high numbers of dolphins in the Ship Channel during October and November dropped slightly in December and leveled out from January to March. The low April count in the Ship Channel, possibly influenced by few trips to the area due to extremely heavy swells, tripled by May when dolphins were recorded following shrimp boats in the upper channel adjacent to Section 5, and when immigration of a diversity of fishes may have occurred. Simmons and Hoese (1959) found abundant young southern flounder (*Paralichthys lethostigma*) moving from the Cedar Bayou outlet into the bays during March through May 1958. According to Stokes (1977), maximum immigration of flounder (*Paralichthys*) occurred between February and April 1974-1975. Simmons and Hoese (1959) noted movement of spotted seatrout (Cynoscion nebulosus) from the Gulf into the bays from late March until late June 1950. They also observed intense migration of Atlantic croaker (Micropogon undulatus) into the Gulf of Mexico during the summer of 1951. Gunter (1945) and Miller (1965) took a majority of croakers from the bays during the spring and reported that they became more common in the Gulf during the summer. Miller (1965) suggested that spot (Leiostomus xanthurus) may have moved out of the bays in the late spring and agreed with Gunter's (1945) contention that sea catfish (Galeichthys felis) moved into the bays during the spring. Hoese and Moore (1977) stated that ribbon fish (Trichiurus lepturus) were most common in the bays during the warmer months, and, following a winter or early spring spawn in waters deeper than 36 m, the young recruit to inshore waters.

Most dolphins observed in the Matagorda Ship Channel in June, July, and August, were seen in association with shrimp boats. Estimated density remained stable although a slight decline was evident as the summer progressed.

Section 2 ranked fifth out of six in the total mean number of dolphins/km^2 during the year. Density values were erratic in this section and declined and increased throughout the year. The majority of dolphins found in Section 2 were usually recorded feeding, mating, or traveling along the Peninsula shoreline in Grids 21 to 26. Dolphins noted farther north and northwest in the section were most often in transit, sometimes mating, but rarely feeding. The decrease in numbers from September to October was followed by a steady increase from October until January. Another decline in density occurred from January until March. Although all other sections of the study area experienced a dramatic decline during April, density in Section 2 increased from March to April. The concurrent decline in Section 6, the decline to virtually no dolphins in Section 4, the high counts farther north towards the middle of Matagorda Bay, and the general sighting of several "natural tags" farther north in the study area may have indicated a shift north towards the middle of Matagorda Bay that caused Section 2 to experience a temporary increase in estimated density. The majority of dolphins observed in late spring and through the summer were recorded in Grids 21, 22, and 23, an area of deep channels extending directly from Pass Cavallo and surrounded by extensive shallow areas along the Peninsula interspersed with deep troughs. Density declined somewhat in May and remained fairly constant through the summer until a noticeable August decline.

Section 4, although less than one-third the size of Section 2, exhibited consistently higher estimated density during much of the year. The shoreline area of Section 2, when viewed separately from its open bay waters, exhibited similar movements and estimated density as that of Section 4, except that its density values were dampened by the extra 12 km^2 included in Section 2. The increase in dolphins seen in Section 2 in April, particularly in the grids closest to the Pass, were in contrast to the decline and virtual absence of dolphins in Section 4 and may have been due to the northward movement of dolphins from Section 6 into Section 2 and from Section 4 towards the middle of the Bay.

Section 4 ranked third in overall estimated density for the year (following the Matagorda Ship Channel and Pass Cavallo). The general increase in numbers from September until January was particularly evident during October and November when shrimp boats were numerous in the area. Also, following fall and winter northers, when the Bay calms and waters warm, many fishes move out of the deeper holes and troughs onto the flats along the Peninsula in order to feed (R. Alan Charles, pers. comm.). This and the close proximity of Section 4 to the Matagorda Ship Channel and its tidal influence upon fish movements could have played an important part in the constant presence of dolphins along the shoreline. The presence of dolphins in these areas during the fall and winter likewise may have been related to fish movements towards the deeper troughs near the Peninsula and deeper portions of the Ship Channel and the Pass. The striking decline of dolphins in Section 4 began in April and continued erratically through the remainder of the study. During that period, fish were reported especially plentiful near the oil wells and platforms in the center of Matagorda Bay (R. Alan Charles, pers. comm.). Shrimp boat activity in those areas was also heavy. The observation of Little Chopped approximately 11 km north of the Peninsula bulkhead, as well as several observations of 20 to 50 dolphins farther north in the Bay suggested the possibility of increased seasonal transit to the middle of the Bay during the spring.

Section 5 estimated density was lowest of all six sections during the entire year, and appeared to be closely related to the movements of fishes and presence of working shrimp boats. Density during late summer through early October 1978 remained high and constant with large numbers of *Tursiops* repeatedly feeding along the shoreline northwest of the Port O'Connor jetties towards Indianola Harbor as well as following shrimp boats working in the area. Shrimpers harvested white shrimp (*Penaeus setiferus*) on the flats near the Matagorda Ship Channel from July until October, at which time they moved to areas north and northeast of the Peninsula bulkhead in order to harvest brown shrimp (*Penaeus aztecus*). Dolphin density in Section 5 also dropped in October, increased slightly during November, and remained erratic and low during the next several months until June. Increased shrimp boat activity in June coupled with an abundance of trout northwest of the Port O'Connor jetties (Grid 57) and northwest along the shoreline troughs towards Indianola Harbor, were reflected in steadily increasing numbers which peaked in August.

Dolphins in Section 6 were regularly found inside the Port O'Connor jetties, the Intracoastal Waterway between the jetties and Fisherman's Cut, the Army Cut, Big Bayou, Saluria Bayou, and Devil's Elbow, although abundance varied on a seasonal basis. Following a slight September to October decline in numbers, population density in the section steadily increased from October until the end of February. Higher concentrations of dolphins were recorded in Grids 81 to 85 and 75 to 78 than were found there during other times of the year. Dolphins were especially abundant in the Intracoastal Waterway in January and February during mullet runs. According to Hoese and Moore (1977), large schools of mullet depart the bays in the fall and smaller schools return over a six-month period. In general, few dolphins were found in the Intracoastal Waterway and Army Cut during the winter, possibly because the two other channels to the southeast (Big Bayou and Saluria Bayou) were deeper, warmer, and more productive. By March, estimated population density in Section 6, primarily in Saluria Bayou, had declined by nearly one-half. This, with the exception of the sharp Section 4 decline during February and March, was the largest decline in the study area. It also corresponded with a tremendous increase in boat traffic in Saluria Bayou and Mitchell's Cut during the late February to early April black drum (Pogonias cromis) run. Fifty to 75 pleasure craft were regularly counted in Saluria Bayou. Although Tursiops seemed little affected by boat traffic in regions of the study area which were well-traversed on a regular basis (the Intracoastal Waterway), the sudden presence of so many boats in the constricted area of Saluria Bayou which had been virtually isolated for several months and had supported densely packed herds throughout the winter, may have influenced, and possibly hastened, the dolphins' movements out of the area. The entire study area density declined from February to March, with the majority of dolphins apparently departing from Sections 4 and 6. Section 6 density declined by over half from March to April, and again by half from April to May. A slight increase occurred in June and July, but by August density had dropped to its lowest point for the entire year.

Aerial Observations

Barham et al.'s (1980) aerial surveys on 26, 27, 28 and 30 March and 1 April 1978 were conducted along 160 km of the central Texas coast from the Aransas Pass area northeast to the base of the Matagorda Peninsula. Covering 17% of the total area during each replicate, they arrived at a mean estimated density of 0.752 Tursiops/km^2 (SE = 0.074). Highest density estimates were obtained in the Aransas Pass area which accounted for only 6.6% of the total area surveyed but contained 23% of the estimated total number of dolphins. The value of 2.63 Tursiops/km^2 in the Aransas Pass area was approximately 4.25 times greater than the 0.619 Tursiops/km^2 estimated from the remaining transects. It is interesting to note that some of the regions in the

Pass Cavallo area which tended to have highest concentrations of dolphins (Intracoastal Waterway, Saluria Bayou, Devil's Elbow, Ship Channel jetties) were those most similar (albeit far smaller) to Shane (1977) and Shane and Schmidly's (1978) study area of deep, protected channels and extensive shallow areas.

When Barham et al.'s (1980) Aransas Pass density estimates are excluded, the remaining value of 0.620 Tursiops/km^2 is very close to the Pass Cavallo spring population estimate of 0.640 Tursiops/km^2, which was the lowest estimated density in the study area over the entire year. Assuming that many of the dolphins moved north in Matagorda Bay or southwest into Espiritu Santo Bay, the aerial survey counts may have included those dolphins which could not be accounted for at Pass Cavallo because they had left the area. The mean density estimate for the Pass Cavallo area over the entire year (0.931 Tursiops/km^2) may be a more accurate value.

"Naturally Tagged" Dolphins

The use of natural markings to recognize individuals in order to undertake in-depth studies of movements, range, behavior, and sociality without disturbing the animals has been discussed by numerous authors (Caldwell, 1955; Norris and Prescott, 1961; Essapian, 1962; Irvine and Wells, 1972; Irvine et al., 1979; Shane, 1977; Shane and Schmidly, 1978; Würsig and Würsig, 1977; Wells et al., 1980; Norris and Dohl, 1980). Although the majority of "naturally tagged" dolphins in the Pass Cavallo area were identified by distinguishable dorsal fin characteristics or by unique, pronounced body scars, a more unusual means of identification reinforced many impressions regarding distribution and home range, posed new questions about short-term movement, and shed light upon the disease "Lobomycosis".

Lobomycosis

Lobomycosis, a chronic disease of the dermis, was originally believed to be restricted to humans in South America. Characterized by the development of thick, verrucose, crusty lesions, diseased areas most commonly occur on the legs and ear lobes, as well as on the face, arms, and buttocks. The disease, caused by the fungus Loboa loboi, was reported by Migaki et al. (1970) in a bottlenosed dolphin from the west coast of Florida. Caldwell et al. (1975) later described six sight records of several suspected cases of dolphins infected with Lobomycosis in Florida waters and cited two previously confirmed infections. During this study, three diseased animals within a 45 km^2 region of the study area were observed and other similarly-infected dolphins were reported. Kalypso was monitored over a period of 12 months, Maverick was sighted twice, and Xenon was observed a single time. The numerous sightings of Kalypso, and lack of such sightings for the latter two animals, inadvertently provided information concerning home range delineation, boundaries, and general movement, as well as insight into the behavior and sociality of diseased animals.

Maverick was initially sighted approximately 1 km northwest of the Port O'Connor jetties at 1330 h on 25 June 1979 traveling south with two juveniles. A pinkish-white, thick, wart-like scarred area was consistent all over the dorsal surface from the sides and top of the head, particularly around the blowhole, to anterior to the dorsal fin, and laterally towards each flipper. After accompanying one of the smaller animals for several minutes, Maverick then continued traveling alone, expelling several loud puffs and expulsive breaths identical to the exhalations sometimes produced by large Tursiops when calves approached the observation platform. The three animals proceeded south to the Port O'Connor jetties where eight to 10 dolphins milled around. It was not noted if the newcomers interacted with any of the dolphins because several large vessels simultaneously moved in and out of the jetties. After the boats passed, Maverick was observed randomly moving several meters south of the south jetty, although the two smaller dolphins could not be located. At 0640 h the following morning, 26 June 1979, Maverick was again observed traveling south, north of the north jetty. Two other Tursiops were also observed traveling south towards the jetties but could not be positively identified as the accompanying dolphins from the previous day. Maverick was not observed during the remainder of the study.

Xenon was sighted only once during the study while following the shrimp boat "Estelle" from 0920 h until 0957 h on 12 July 1979 in the extreme northwesternmost periphery of the study area, 0.5 km west of the Matagorda Ship Channel. Xenon, an unusually large dolphin at least 320 cm long, was covered with a thick, verrucose, whitish-pink crusting from the trailing edge of the dorsal fin to the posterior aspect of the tail flukes. "Estelle" was towing to the northwest, circled around at 0945 h, and began moving south, at which time Xenon disappeared. Although the two other Tursiops continued to follow the boat, they hung far back from the stern and within a few moments began following the shrimp boat "Miz Phil" which was towing to the northwest. Xenon was not noted again during the study.

The lesions on "naturally tagged" Kalypso were far less extensive than those observed on Maverick and Xenon and formed small patches on the right side of the dorsal fin, just anterior and posterior to the right side of the fin, near the leading edge of the left side of the fin, and immediately anterior to it. Several scratches were also noted on the right side of the body near the fin. The verrucose tumefactions were white, in contrast to the pinkish-white crusts observed on Maverick and Xenon. Little change in the lesions was observed until approximately 1 year later when the size of the patches on the left side of the body appeared to have increased.

Eighty-eight percent of Kalypso's 24 sightings were recorded within protected areas or channels, namely the Intracoastal Waterway, Big Bayou, Saluria Bayou, and Devil's Elbow. Nearly one-fourth of those sightings involved travel from the above-mentioned areas towards Pass Cavallo and/or Matagorda Bay. Kalypso was observed alone upon three occasions (12% of the time), traveling within a pod 42% of the time (with no other dolphins in sight) and within a herd 46% of the time. Goal-oriented travel constituted the most prevalent activity, comprising 58% of all recorded behaviors. Random movement, feeding, and mating each constituted 14% of all observed behaviors.

Caldwell et al. (1975) stated that most collections and observations of diseased animals were made in protected waters, or, when farther from land, in shallow protected waters or shallow waters in the ocean near inlets to protected areas. They also pointed out that all animals were large, and some, such as a dolphin captured in 1955 which measured an estimated 425 cm, were extremely large. Two of the diseased dolphins they observed were noticeably emaciated. It appeared that the most serious infections occurred over areas most often exposed to air (top of the head, top of the caudal peduncle, and tail flukes).

This investigator's observations corroborated many of Caldwell et al.'s (1975) preliminary conclusions. Maverick and Kalypso were presumed to be adult animals 244 to 275 cm long. Xenon measured at least 320 cm. None of the three dolphins appeared emaciated or sluggish at any point. Although their ventral surfaces were not closely observed, lesion sites on Maverick and Xenon were concentrated around the blowhole towards the dorsal fin, and from the fin to the tailstock and flukes.

It has been suggested that the distribution of cases indicates greatest susceptibility to Lobomycosis in riverine-estuarine stocks of Tursiops that may therefore be isolated from ocean stocks (Leatherwood, 1979). It should be recognized that the majority of reported cases were observed in conjunction with capture operations that are somewhat limited to inshore, shallow protected areas. Similar efforts to locate infected animals in Gulf near-shore or offshore waters might also result in the discovery of many cases. One reliable observer who had seen Kalypso several times reported many Tursiops outside Pass Cavallo in the Gulf of Mexico with similar wart-like, crusted patches on their bodies (D. Walker, pers. comm.).

The two consecutive sightings of Maverick which constituted the total sightings of that animal during 15 months of fieldwork posed many questions. Why had this dolphin never been noted before during all the months of regular, study area coverage? What areas did it frequent? What, suddenly, was it doing in the study area for a limited 2-day period, and why? What was the relationship between it and the two smaller Tursiops, neither of which was a young calf? Caldwell et al. (1975) indicated that infected animals were observed both in the company of other diseased animals and healthy animals. Irvine et al. (1979) found that young males formed bachelor groups which sometimes included one or two females, and this may have been the case here. Due to the pod's rapid goal-oriented travel to the south while remaining close to the Matagorda Bay shoreline, they may possibly have originated farther north or northwest in the Bay. Maverick may have been "Old Scarback", the dolphin local shrimpers believed frequented the Matagorda Ship Channel as well as the Ferry Channel in Espiritu Santo Bay. If so, Maverick may have been observed while traveling between the two areas. Nevertheless, it seems unlikely that Maverick would not have been sighted more than a single 2-day period during the entire 15 months of fieldwork.

Local shrimpers also stated that Xenon was not "Old Scarback". The lack of sightings of Xenon seemed to indicate that its home range was not within the study area. Although Xenon was assumed to frequent the area to the northwest and north of Indianola, this dolphin may have ranged slightly farther south than it normally would have done had it not been following a shrimp boat. The fact that Xenon disappeared immediately after the boat began towing to the south, (away from its presumed home range area) and the fact that the two other pod members almost immediately switched to a boat which was towing to the north, may have indicated their preference for remaining in certain areas. The southernmost sighting of another "natural tag", Ourania, was also recorded as she followed a shrimp boat several kilometers south of the areas in which she had previously been sighted.

The chance single sighting of Xenon at the edge of the study area reinforced the impression that Tursiops maintain consistent home ranges of unknown number and size, or at least prefer certain areas over others and most probably do not roam widely in a haphazard manner. The brief, ephemeral encounter with Maverick may also have been indicative of movement to a second home range, although the total lack of sightings remains a mystery. For that reason, the suggestion that an unknown amount of random travel may occur through rarely-frequented regions cannot be ruled out.

Kalypso was seen on a fairly regular basis between 26 July 1978 and 30 July 1979. This dolphin's physical condition appeared stable, although the Lobomycosis lesions possibly spread somewhat on the left side. Kalypso never exhibited any signs of illness, including emaciation or sluggishness, and was noted undergoing strong, goal-oriented travel much of the time. The disease did not appear to act as an isolating factor and Kalypso was seen in the company of other dolphins 88% of the time, and was noted actively mating upon four occasions. Also, although nearly all sightings of Kalypso were recorded in protected waterways or small embayments, several of the other "natural tags" in Herd Range I frequented virtually the same areas.

The opportunistic observations of Maverick and Xenon, and the more regular sightings of Kalypso, as well as their presence with other animals, large size, and seemingly usual manner of travel and feeding, affirm Caldwell et al.'s (1975) statement that affected individuals appear to live at least several years in the unattended, wild state.

Home Range

Caldwell (1955) originally proposed the idea of a home range for Tursiops. Although it was possible to define the home range limits of several "natural tags" within the study area, the travel and movement that may have occurred outside the area between consecutive sightings and during sporadic and seasonal absences made it difficult to pinpoint the scope of home range utilization. The sighting of Thick Fin on 29 June 1979 exemplifies both the degree of movement possible in a limited period of time as well as the potential use of two or more home ranges connected to each other by a traveling range (Caldwell and Caldwell, 1972a) or the use of a single, large expansive range.

Thick Fin's synthesis of both bay and channel inshore areas and the Gulf near-shore area into one or more ranges is unclear at this time. It has been assumed that Tursiops which frequent the bays and channels constitute a group separate from those normally found in the near-shore Gulf (Shane, 1977; Shane and Schmidly, 1978). Had the investigator been unaware of Thick Fin's previous whereabouts, he would have been considered a near-shore Gulf Tursiops that had never been observed in Matagorda Bay.

In the Pass Cavallo area, although several dolphins including Kinara, Kalypso, Pointed Finger, Little Chopped, and Aliki were seen fairly regularly throughout the year, the majority of consecutive sightings were separated by intervals of several days to several weeks. These "natural tags" were considered resident dolphins; however, they may have traveled long distances away from the study area with regular returns to it. A single home range extending an unknown distance from the study area, or a second home range, with a traveling range between it and the home range which overlapped with the study area may have been utilized. The dolphins did not necessarily travel out the Matagorda Ship Channel jetties or Pass Cavallo into the Gulf of Mexico to offshore areas or to points northeast and southwest along the coastline. They may have instead ranged farther north and northeast in Matagorda Bay, or farther southwest in Espiritu Santo Bay. In the case of Ourania and her calf, the degree to which Powderhorn Lake was utilized in conjunction with other areas is unknown.

Sightings of "natural tags" within the study area consistently occurred in the same regions. The fact that Ragamuffin, Tal, Gil, and Huckleberry were not observed until the spring and summer of 1979, after which they were recorded in Herd Range I, may have been due to their movement into the area from a fall and winter home range located elsewhere. Shane (1977) and Shane and Schmidly (1978) stated that Thick Fin maintained one home range within their study area, and presumably held a second home range outside the area during the winter. The sporadic nature of the subsequent sightings of Ragamuffin, Tal, Gil, and Huckleberry may have been due to time shared in two areas.

The unconfirmed sighting of Echo in Espiritu Santo Bay (October 1978) followed by two summer sightings in Matagorda Bay, suggests that Echo's most regularly-frequented home range was located in Espiritu Santo Bay. Rare visits farther northeast to Matagorda Bay were made. Stubby, noted traveling southwest along the southwestern periphery of the study area during three of the four sightings in the spring and summer, may have had a single home range that extended several kilometers farther into Espiritu Santo Bay (outside the study area), or may have held a second home range farther southwest in that bay.

Irvine and Wells (1972), Shane (1977), and Shane and Schmidly (1978) found evidence demonstrating the use of home ranges. Irvine et al. (1979) identified a littoral population of dolphins with a definable home range. Shane (1977) and Shane and Schmidly (1978) stated that two major herd ranges appeared to exist in their study area, and Irvine et al. (1979) stated that the dolphins in their study area separated into one to two discrete social units. During this study, although a large amount of overlap among individual ranges existed, little intermingling or overlap was recorded among the three herd ranges.

Flag and Kalymnos represented an apparently different group of dolphins usually observed near, at the ends of, or just outside the Matagorda Ship Channel jetties within a few kilometers of the Gulf beach. Their home ranges were assumed to be primarily restricted to the near-shore Gulf of Mexico. Shane (1977) and Shane and Schmidly (1978) also discussed the existence of an offshore population and observed "Southpaw" a single time following a shrimp boat outside the north jetty of Aransas Pass on 1 August 1976. They also noted that the study area dolphins seemed to mix quite easily with the Gulf dolphins. This was never noted in the Pass Cavallo area. Odell (1975), Mitchell (1975), and Winn et al. (1979) discussed Gulf populations of Tursiops, and Winn et al. (1979) suggested that inshore populations included "ocean" porpoises and "river" porpoises in addition to a third group of Tursiops found far offshore.

The sighting of Thick Fin near the Gulf beach on 29 June 1979 raised many questions regarding the inshore-Gulf of Mexico distribution and segregation of Tursiops, use of the Gulf by dolphins considered to inhabit inshore bays and channels (and vice versa) and the general nature and utilization of home ranges, which may not be employed on a seasonal basis. Although Thick Fin was assumed to have a second range elsewhere, he was regularly observed in the inshore waters of the Aransas Pass area, and was considered to be a "study area" dolphin in contrast to the Gulf dolphins which came extremely close to the study area but were almost never observed entering Aransas Pass (Shane, 1977; Shane and Schmidly, 1978).

Seasonal Movements

An increase in estimated dolphin density beginning in late October was noted primarily along the southern and eastern borders of the study area from Devil's Elbow northeast along Saluria Bayou, into Pass Cavallo, and along the Matagorda Peninsula shore northeast to the bulkhead. Much activity during the fall was apparent at the ends of the Matagorda Ship Channel jetties and in the near-shore Gulf. By winter, the large herds of dolphins along the Matagorda Peninsula from Decros Point to the Ship Channel were less apparent and January increases were followed by a February decline. However, consistently high numbers of dolphins were regularly observed in Pass Cavallo, Saluria Bayou, the Saluria Bayou-Pass Cavallo intersection, Devil's Elbow, Bayucos Point, and Big Bayou. Dolphins noted southwest of Devil's Elbow were usually in transit either towards Espiritu Santo Bay or northeast towards Saluria Bayou. In March, a predominance of movement between Pass Cavallo, through Saluria Bayou and Devil's Elbow southwest towards Bayucos Point and Espiritu Santo Bay was evident.

From winter through late March, extensive activity was noted in the deep marshland channels and adjacent shallows, and in Pass Cavallo and the Matagorda Ship Channel. Irvine et al. (1979) found a virtual absence of Tursiops in the channels, bays, and flats during the winter with concomitant increases in the passes, Gulf beach, and offshore Gulf. Hoese (1971) stated that Tursiops moved into the deep channels and Gulf during the winter in order to feed. The Gulf beach was rarely covered during this study, so it is not known if increased numbers frequented that area. However, the presence of mating and playing dolphins in shallow areas adjacent to the deep channels where they fed was often recorded. Shane (1977) and Shane and Schmidly (1978) also noted winter congregations in the shallow Morris and Cummings Cut area and suggested that temperature might not be the major factor in movements and distribution.

The seasonal variation in estimated dolphin density within the study area indicates that additional Tursiops utilized the region during the late fall and winter 1978-1979 and that a sharp decline in estimated density followed during April. Movements of "naturally tagged" dolphins strongly suggested the possibilities of single, large home ranges or of additional home ranges. A dramatic winter-to-spring increase in number of sightings of Kinara coupled with a summer decline may have indicated that Herd Range I encompassed only a small portion of Kinara's entire home range, or that it constituted an additional range that was utilized from time to time, most heavily during the spring. A similar trend was noted for Kalypso who was sighted far less frequently during the fall, winter, and summer than during the spring. Aliki was absent from the study area during the fall, and rare sightings during December, January, and February were recorded. An increase in March was noted and a subsequent summer drop also occurred. It is possible that the increased numbers of dolphins in the channels and Pass during late fall and through the winter might have been related to movement of many of the "natural tags" to areas away from that region. In March, the month in which a sharp increase as well as initial appearance of several "natural tags" occurred, estimated density in Section 6 declined. Ragamuffin, Tal, Stubby, Gil, and Huckleberry were noted in the study area only during the spring and summer months and may also have moved into the area on a seasonal basis. Although Pointed Finger did not exhibit the large seasonal differences in sighting occurrence that were noted for Kinara and Kalypso, the nearly year-round observations were not numerous enough to preclude extensive movement outside the study area as well. Winter whereabouts of Gash and Ourania were unknown, and Little Chopped's extended absence from the study area during most of the spring and summer was attributed to movement farther north in Matagorda Bay. Although none of the other "naturally tagged" dolphins was noted as far north as Little Chopped, an increased number of Herd Range I dolphin sightings were made to the north in the Bay portion of Herd Range I. This spring and summer shift from the marshlands to Matagorda Bay was evident in density trends of the individual sections as well as by the increased sightings of Kinara, Kalypso, Pointed Finger, and Aliki in Matagorda Bay. Movement out of Pass Cavallo and the Matagorda Ship Channel jetties into the Gulf of Mexico cannot be discounted and localized linear movements along the Gulf beach between the Pass and Ship Channel may have occurred. Odell et al. (1975) stated that a certain amount of migration occurs to and from inshore and offshore areas, as well as linearly along the coastline.

The variation in seasonal abundance apparent in the study area is in direct contradiction to Gunter's (1942) statement that seasonal variation of abundance and migration are nonexistent in Texas waters. The evidence is also strong for the seasonal utilization of particular regions of the study area. Irvine et al. (1979) noted distinct differences of habitat utilization according to season, whereby dolphins concentrated in the passes and along the Gulf shoreline during the winter and were more readily found in the bays and inshore channels during the summer. Shane (1977) and Shane and Schmidly (1978) reported higher winter population counts within their study area that resulted from an influx of animals from either the Gulf or from adjacent bay systems. They stated that the seasonal variation in the presence of "natural tags" and monthly variation in dolphin numbers within the study area indicated seasonal movement. It is still unclear whether the variation in abundance seen in the Pass Cavallo area resulted from a relatively localized, regional shift of dolphins from areas of Matagorda Bay and Espiritu Santo Bay into the deeper, more productive marshland channels, Pass, and Ship Channel, or if more long-range movement (such as Thick Fin's coverage of at least 190 km) occurred.

The general movement of fishes in the fall towards the warmer, deeper channels, deep troughs and holes throughout the study area, as well as emigration towards the Gulf was reflected by similar movements of dolphins to those areas. Although True (1980), Caldwell and Caldwell (1972) and Hogan (1975) have reported seasonal migration for Tursiops along the Atlantic coast, Irvine and Wells (1972) found no evidence of seasonal migration in central west Florida. Würsig (1978) recorded six Tursiops in one area from August 1974 until October 1975. The same dolphins were observed 300 km away 6 months later. Four of the six were sighted in the original area once more by December 1976. However, because Würsig (1978) found recognizable individuals throughout the year, he stated that the dolphins in his study area did not migrate with the changing seasons.

Daily Movements

"Time-Group" Sightings

The extent of movement between sightings of "natural tags", regardless of days involved, was difficult to determine due to the variability of movement exhibited within even a period of a few hours. Dolphins were often observed in goal-oriented travel and easily covered 6 to 7 km within 45 minutes, thus suggesting the coverage of large distances during each "time-group" sighting interval. On the other hand, they were also observed for several hours at a time within limited areas no larger than several hundred square meters. Upon still other occasions, travel and other activities were combined and dolphins slowly traveled in a specific direction with frequent pauses in order to mate, feed, or randomly move. After several minutes to several hours they would continue their slow, forward progression in the same or in a different direction. Aliki was sighted and followed four times on 12 February 1979; at 1000 h traveling northeast in the Intracoastal Waterway near Fisherman's Cut; at 1100 h milling with several other dolphins outside the Port O'Connor jetties 2.2 km to the northeast; at 1212 h at Fisherman's Cut in Barroom Bay, randomly moving and feeding; and at 1507 h, 7.3 km to the southwest, rapidly traveling through the Army Cut and continuing northeast in Espiritu Santo Bay. On 6 August 1979, movements of a herd of 25 Tursiops, including Ragamuffin, were monitored for over 5.5 hours. Although a variety of activities was recorded most of the herd remained intact and within an area measuring less than 2 km^2 during the entire period.

The above descriptions illustrate that dolphin activities involved both rapid coverage of large distances and almost aimless and random movement within a small area for several hours. Shane (1977) and

Shane and Schmidly (1978) stated that dolphins covered long distances quite quickly, and often moved aimlessly around small areas for extended periods of time. The animals also followed certain movement patterns for several consecutive days or weeks, after which the pattern would abruptly be broken.

Spatial Organization

Pilleri and Knuckey (1969) described Delphinus delphis "on parade" in which the entire school swam in a line with groups of two to three animals following one another. Schools were noted slowly swimming in a definite westerly or easterly direction during calm seas and good visibility. Distance among groups remained constant. Although they did not record this formation for Tursiops in the western Mediterranean, "porpoise parades", as they were referred to in the Pass Cavallo area, were recorded many times and were identical to those described by Pilleri and Knuckey (1969). Most occurred in shallow water less than 4 m deep along the length of the Matagorda Peninsula in a northeast or southwest direction, although several "parades" were noted in the Intracoastal Waterway where the extremely large numbers of dolphins appeared conspicuous in the constricted area. Pods remained intact and distance among them was constant. Feeding was never noted. This configuration always appeared striking, perhaps due to the sheer number of animals involved, the consistent, regimented travel, and the impression of a collective herd in uniformly separated pods. Reasons for this mode of travel, whether based upon navigational benefits or social structure, are inexplicable at this time.

Herds of Tursiops were also recorded traveling "en masse", in which the dolphins were assembled more loosely in fluid pods that constantly restructured themselves. Pilleri and Knuckey (1969) recorded this type of group composition for Delphinus delphis and Stenella styx. The amount of space among pods fluctuated and the speed of traveling varied. A less regimented atmosphere prevailed, and mating and feeding were recorded.

"Porpoise parades" appeared to be structured formations geared towards steady, uninterrupted progression to a specific area. "En mass" movement, on the other hand, seemed to be synthesized with group feeding activity and social behavior (mating) as well as the general progression through an area. Würsig and Würsig (1979) described herd configuration and movements that were similar to the "porpoise parades" and "en masse" structure described above. They noted slow, inshore movement in shallow water (less than 10 m deep) in which subgroups progressed in a tight formation 10 to 15 m wide and 50 to 75 m long. No individual was far from shore and all animals were in similar depth due to the narrow formation of the group. Würsig and Würsig (1979) also described a more rapid type of movement which occurred during brief, mid-day periods of non-summer seasons. Dolphins, with greater than usual individual distance among individuals, moved into water deeper than 10 m and advanced as a wide rank which covered a large area. The authors suggested this movement and group configuration might have been a search pattern for schooling fish, especially the southern anchovy (Engraulis anchoita). Because feeding was often associated with the "en masse" movement seen in the Pass Cavallo area, this method of covering large areas in conjunction with forward travel may have been the same type of search pattern recorded by Würsig and Würsig (1979).

A third type of herd configuration mentioned by Pilleri and Knuckey (1969) and infrequently sighted in the open bay area of Section 2 was the "hollow oval". In this configuration, Tursiops assembled in pods of two to five animals around an imaginary inner circle and traveled forward.

Oil Spill

According to Geraci and St. Aubin (1979), investigations of dead marine mammals found at oil spill sites have not conclusively linked the presence of oil with the animals' mortality. Although reports of oil spills, particularly those of the 1969 Santa Barbara Channel blow-out, have implicated oil contamination as responsbile for the deaths of a variety of cetaceans, pinnipeds, and otters, oil was not conclusively determined to be the causal agent.

Geraci and St. Aubin (1979) stated that in some cases pinnipeds and sea otters do not avoid oil, and that some marine mammals may even be attracted to a spill in order to feed on fish and organisms debilitated or killed by the oil. Such an explanation may also clarify the large amount of fish-tossing that was so evident on 27 September 1978 and described herein. Although some Tursiops were observed executing the typical diving and movement patterns associated with food-finding, such as long-dives and flukes-up dives in conjunction with erratic zig-zags and circles, the most noticeable and striking activity concerned the high rate of fish-tossing and playing in the spill area. It is not known how many of the tossed fish were eventually eaten (if at all), nor how much oil was incidently ingested. Geraci and Smith (1976) found that ringed seals rapidly absorbed crude oil hydrocarbons into body tissues and fluids, and ultimately excreted the compounds via bile and urine (Engelhardt et al., 1977). Harp seals given up to 75 ml crude oil showed no clinical, biochemical, or morphological evidence of tissue damage (Geraci and Smith, 1976). Although the authors cautioned against comparing these findings to other groups of marine mammals, they believed the results dampened fears that accidental oil ingestion associated with feeding would be immediately harmful to piscivorous marine mammals. However, the long-term effects of ingestion of naphthalenes and tetramethylbenzene, the hydrocarbon components that are not metabolized by fish and are ultimately transferred to top-level predators (McCain et al., 1978) are unknown. Hodgins et al. (1977) presented evidence that some petroleum hydrocarbons, including benzopyrene, are carcinogens in many invertebrate and vertebrate species.

Cetaceans have yet to be found covered with oil. Geraci and St. Aubin (1979) stated that odontocetes may be able to detect oil more readily due to more sophisticated long-range sensory capabilities (Norris, 1969). Also, cetacean skin is smooth and cannot accumulate oil, and oil-fouled odontocetes may go unnoticed because of their wholly aquatic nature. Although the dolphins may or may not have detected the oil, this investigator's limited observations suggested that they did not avoid it, nor did they appear directly affected by it in a negative manner. Irritation and inflammation of the eyes or skin were not observed, although the possibility of the subsequent appearance of such ailments was not discounted. Shane (1977) and Shane and Schmidly (1978) stated that following an oil spill in their study area, the animals swam regularly through the slick but seemed to avoid surfacing in the heaviest concentrations of oil. They were observed feeding and mating only after they had reached cleaner water, even though the oil appeared to have no obvious effect upon them.

The oil spill's effects upon the movements and behavior of area dolphins was difficult to calculate since the large number of dolphins observed that day engaged in play behavior was also recorded under more normal circumstances, particularly during choppy or rough sea states. Further behavioral observations in oil spill areas, coupled with detailed investigations of strandings, including histological research as well as the plotting of stranding locations and frequencies are necessary before the effects of oil contamination will begin to be understood.

Bay-Gulf Interchange

The extent of movement between Matagorda Bay and the Gulf of Mexico is unclear. Although such movement was observed, it was recorded far too rarely to offer any preliminary conclusions at the present time. Shane (1977) and Shane and Schmidly (1978) noted a tendency for more dolphins to move up than down Aransas Pass throughout the day, and suggested that some dolphins may move out of the Pass into the Gulf of Mexico at night. Saayman et al. (1973) and Norris (1974) noted that both Tursiops aduncus and Stenella longirostris entered the bays in the morning, having spent the night in the sea. During this study, deliberate travel up Pass Cavallo towards Matagorda Bay was especially noticeable in the mornings, while Gulfward movement down the Pass was more common during the late afternoon and early evening. On 24 January 1979, an early evening "porpoise parade" along Matagorda Peninsula reached the southwest tip of the Peninsula (Decros Point), at which time several animals swung around to the east and began traveling down the Pass towards the Gulf.

Social Composition

Subgroups or pods of dolphins that are characterized by varying degrees of permanence and fluidity have been described by several authors (Irvine and Wells, 1972; Irvine et al., 1979; Hogan, 1975; Würsig and Würsig, 1977; Würsig, 1978; Wells, 1978; Shane, 1977; Shane and Schmidly, 1978; Wells et al., 1980; Asper and Odell, 1980). Results of this study suggested that pod composition is versatile and unpredictable, ranging from temporary, changeable bonds and encounters to long-term, enduring relationships among certain individuals.

"Naturally Tagged" Dolphins

"Natural tag" associations illustrated that little interaction among dolphins belonging to different extended herds occurred. Irvine et al. (1979) also noted that naturally marked Tursiops from areas adjacent to their study site occasionally approached groups of the study herd but never appeared to mingle with them.

Herd composition was dynamic and bonds of varying intimacy were noted. Dolphins observed interacting within the same pod were later sighted in the same herd or in different herds. Dolphins previously not recorded within a pod or herd were later noted together. Irvine and Wells (1972) captured the same three large male Tursiops together upon three different occasions, and Asper and Odell (1980) observed two freeze-branded adult males together every one of the nine times in which they were sighted. Two other males were seen together 12 times. Wells et al. (1980) also described the dynamic nature of groups within the study herd wherein particular dolphins were sighted together on consecutive days, after which they were located in new groups and new areas. The original group was sometimes encountered intact once again.

Hogan (1975) reported that group splintering and restructuring was common, but that core groups of five to 10 animals were apparent. Würsig and Würsig (1977) and Würsig (1978) found subgroups of eight to 20 animals that included a small core unit of individuals consistently found together. Other animals appeared and disappeared in the subgroups on different days in a highly fluid manner. Although a fixed core unit of dolphins was not observed in the Pass Cavallo area, the inter-related nature of "natural tags" was evident.

Saayman et al. (1972, 1973) and Saayman and Tayler (1973, 1979) found that humpback dolphins (Sousa) exhibited fluid group structure which involved a variety of individuals. Much regrouping and separation into units different from their original composition was noted. Shane (1977) and Shane and Schmidly (1978) commented that the social units of Sousa appeared slightly less stable than did those of Tursiops truncatus in the Aransas Pass area. In this study, associations of bottlenosed dolphins were changeable over time; intermingling and shifting among groups was often noted, but group cohesiveness and stability seemed more pronounced and less loosely organized than that of humpback dolphins.

Shane (1977) and Shane and Schmidly (1978) described three forms of association among bottlenosed dolphins that were apparent from "natural tag" observation in their study area, including: (1) the casual acquaintance of all dolphins in the area with one another; (2) herd membership or home range-sharing; and (3) pod membership including dolphins who spent much time together in the same pod. During this study, the second and third forms of association were noted. However, because this study area incorporated what appeared to be three extended herd ranges with little overlap, it was assumed that not all animals in the study area were acquainted with one another.

Mean Pod and Herd Sizes

Singletons comprised 10% of all sightings of dolphins in the Pass Cavallo area. This value was similar to Irvine et al.'s (1979) calculation of less than 15% singletons, and indicates the gregarious nature of bottlenosed dolphins. Pod size, which averaged between two and four dolphins in this study area, was slightly smaller than other inshore Gulf region pod sizes that ranged from three to eight animals (Leatherwood and Platter, 1975; Shane, 1977; Shane and Schmidly, 1978; Irvine et al., 1979; Leatherwood, 1979; Barham et al., 1980).

Individual pod sizes were significantly larger in the open bay areas of this study compared to the marshlands. Leatherwood (1975) also found that subgroups in the marshlands tended to be smaller than those in the sounds. Mean herd sizes in the Pass Cavallo area also tended to be larger in the open bay areas as compared to the marshlands. Leatherwood and Platter (1975), Wells (1978), Shane (1977), Shane and Schmidly (1978), and Irvine et al. (1979) also noted larger group sizes in the less constricted regions of their study sites. However, it should be noted that periodically, particularly during the winter and early spring, extremely large herds of dolphins, often in transit, were observed in the Intracoastal Waterway, Saluria Bayou, and Devil's Elbow. With the exception of "porpoise parades", herds in Matagorda Bay were more cohesive and less strung out than were herds in the constricted marshland channels. A similar finding was mentioned by Leatherwood (1975) regarding herd structure in the sounds and marshes of the northern Gulf of Mexico.

The general decrease in both pod and herd sizes during the fall and winter was also noted by Shane (1977) and Shane and Schmidly (1978). Irvine et al. (1979) found a general increase in pod sizes during November and December.

Group sizes of Tursiops in the waters of the southeastern United States appear to be smaller than those of other areas of the world. Pilleri and Knuckey (1969) found Tursiops truncatus in groups ranging from eight to 100 individuals in the western Mediterranean, and Würsig and Würsig (1977) and Würsig (1978) noted that group sizes of bottlenosed dolphins in their study area along the Argentine coast ranged from eight to 22 animals, with a mean of 15 individuals per group. The mean group size of Tursiops aduncus off the coast of South Africa was 140.3 (Saayman and Tayler, 1973), far less comparable to Tursiops truncatus in Texas waters than was the 6.6 mean group size observed in humpback dolphins (Sousa).

Female-Calf Pairs

Calf percentages of approximately 7 to 10% have been reported by Leatherwood and Platter (1975), Shane (1977), Shane and Schmidly (1978), Irvine et al. (1979), Leatherwood (1979), Asper and Odell (1980), and Barham et al. (1980). Odell and Reynolds (1980) stated that their relatively low values of 2.1 to 2.5% calves may have been a function of the location of their study area. The Pass Cavallo area mean percentage of 7.21 calves for the year is quite comparable to Shane (1977) and Shane and Schmidly's (1978) 7.61% calves. March and April 1978 aerial surveys along the Texas coast classified 9.3% of the total animals sighted as calves (Barham et al., 1980). This study's March and April calf percentages were 9.09 and 8.76, respectively.

Leatherwood and Platter (1975) calculated that the 7.7% calves they observed were indicative of a healthy population if the calving interval was 3 years, but was below maximum productivity if the interval was 2 years. Speculation about a 2-year calving cycle increased during this study following three confirmed sightings (and several other possible sightings) in January and July 1979 of pods containing a newborn infant, an older calf, and a larger animal, presumably the mother. A bimodal calving season (Harrison and Ridgway, 1971; Sergeant et al., 1973) from September to November and February to May has been suggested for both captive and free-ranging Tursiops. Irvine et al. (1979) stated that they were unable to determine if their calf sightings represented a bimodal breeding season with peaks in late spring and fall, or a continuous spring-to-fall breeding season. Shane (1977) and Shane and Schmidly (1978) found small calves throughout the year and suggested that Tursiops are born throughout the year with a peak in late spring. This appeared to be the case in the Pass Cavallo area, although the high percentage of newborns in early January is inexplicable at this time.

The calf percentage histograms from Shane (1977) and Shane and Schmidly (1978), and Irvine et al. (1979) and this study are all comparable. Highest calf percentages in Florida, ranging from 10 to 14%, occurred during September, July, June, and November. During the remainder of the year, calves comprised between 3 and 7% of the total sightings. Shane (1977) and Shane and Schmidly (1978) found the highest calf percentages of 10 to 13% during April and May. Calves constituted 3 to 8% of the total sightings during the remaining months of the year. There was less variation among calf percentages during this study in which the values for all 12 months fluctuated between 5 and 10%. Calves comprised 5 to 7% of the total population during September, October, November, December, February, and August, and 8 to 10% of the total sightings during January, March, April, May, June, and July. Calf percentages in Florida and in the Aransas Pass area were lowest during March and February, respectively. In the Pass Cavallo area, calf percentages were lowest in December, while the March value was second highest of the year.

The fall and winter calf percentages were nearly equal, although a striking increase of newborns was noted during January 1979. Layne (1965) recorded two recently born Tursiops that had stranded in December and January. The newborn calves of January 1979 were the first newborns observed during the study, and no others were recorded until 3 March 1979 and 14 March 1979, when two fresh newborn or stillborn calves were found on the Matagorda Peninsula Gulf beach and on the Matagorda Bay shoreline several hundred meters northwest of the Port O'Connor jetties. On 27 March, a newborn calf was observed traveling with a herd of 15 dolphins in the vicinity of the Gulf and Pass Cavallo.

Irvine et al. (1979) stated that numbers of female-calf pair sightings varied with season and habitat, suggesting the use of certain regions which offered protected waters and readily available food sources as nursery areas. They also found that females with calves exhibited the most extensive home ranges of any of the age-sex classes, although they tended to concentrate in the more productive northern region of the study site, an area of shallow, submerged grass flats. A high percentage of female-calf pairs during this study frequented the protected channels and grass flats of the marshlands. The recording of 63% of all female-calf pairs within the marshlands during the winter of 1978-1979 suggests their preference for those areas.

Herd Composition

Leatherwood and Platter (1975) observed herds containing discrete subgroups of adults, juveniles, females with calves, and females with one calf and one juvenile during their aerial surveys off Alabama, Mississippi, and Louisiana. Similar composition was found in the Pass Cavallo area in which variously-sized animals could be noted within the larger unit. Most evident were the segregation of female-calf pairs and juveniles within the herd. Irvine et al. (1979) stated that females accompanied by calves traveled throughout the range and appeared to interact less with adult males than did unaccompanied adult and subadult females. Hogan (1975) also stated that variously-sized dolphins could be seen in the large, temporary aggregations in the late summer and early fall. Infants were accompanied by one and sometimes two large animals, and subgroups of juveniles could sometimes be distinguished within the larger aggregation. The age-size classes of small groups appeared fairly constant, and groups of large dolphins rarely included smaller animals, and vice versa.

Irvine et al. (1979) stated that adult males were often found together and interacted to a greater extent with females of all ages and all classes in general than with subadult males. During this study, large Tursiops, possibly males, were never noted interacting with pods of juveniles. One exception may have occurred on 6 August 1979 when several young dolphins were noted repeatedly lunging at three large dolphins, executing non-stop leaps and forward trunk-slaps, nearly touching the adults each time. The encounter appeared unusual due to the playfulness of the juveniles and total lack of participation by the adults. None of the mutual physical contact so common during mating or playing was evident as the adults totally ignored the juveniles. The animals were not sexed and it is unknown whether the encounter may have been an example of a confrontation between adult males and juvenile males.

Sexually segregated groups of bottlenosed dolphins were also noted by Caldwell and Caldwell (1972a), Irvine and Wells (1972), and Mead (1975a). Tavolga (1966) noted subgroups of single adult males, adult females, and mostly male subadults and juveniles at Marineland of Florida.

Dolphin - Shrimp Fishery Association

Gunter (1938, 1942, 1951, 1954), Norris and Prescott (1961) and Caldwell and Caldwell (1972a) have all briefly described the attraction of Tursiops to shrimp boats. Hogan (1975), Leatherwood (1975), Shane (1977) and Shane and Schmidly (1978) have gone into somewhat more detail depicting and categorizing this feeding pattern. However, accounts based upon consistent, recurrent observations of dolphins associating with shrimp boats over a period of months, and the implications of such a relationship upon feeding ecology, sociality, inter-specific interactions and movements are not available.

Major Stages of Operation

Docked or Anchored Non-Working Shrimp Boats. When dolphins were observed in the vicinity of docked shrimp boats at Clark's Fish House on the Intracoastal Waterway, they sometimes veered off to enter the boat slips. They were also sometimes observed near shrimp boats that were still culling out the last tow. Five to 10 dolphins milled around several boats and fed on trash fish that were discarded in the Intracoastal Waterway.

Leatherwood (1975) described dolphins' attraction to boats anchored in the bays and sounds during the day following a night of shrimping. Remnants of debris and trash fish still entangled in nets left trailing in the water or hanging from the outriggers were apparently attractive to the animals. Several similar cases were recorded in Matagorda Bay, and on 13 January 1979, three dolphins including one calf had approached and milled around the project boat for over 30 minutes when they abruptly racing-dove towards a Gulf shrimp boat anchored 0.5 km southwest of the Ship Channel jetties. On 9 July 1979, 5 hours were spent observing aboard the "Capt. Morocco", which was anchored 300 m off the Matagorda Peninsula and about 0.5 km southwest of the Ship Channel jetties. Several pods of dolphins were counted during the 5-hour period, although none of them approached the boat or altered their course in any way.

Large herds of Tursiops around anchored boats with crews still culling out, as well as following completion of culling out, were often recorded at night. They encircled the entire boat and short- and long-dove, leaped, interacted with one another, and frequently snorted in an energetic fashion. The loud and frequent snorts, expulsive puffs and breaths may have also commonly occurred during the day but were inaudible due to the engine's loud noise. Although it was assumed that night feeding on trash fish discarded from the last tow occurred, it was too dark to see any fish in the mouths of the dolphins.

Underway To or From Shrimping Grounds. Dolphins were regularly noted at the ends of the Port O'Connor jetties randomly feeding, mating, or milling around. Many times an atmosphere of almost aimless "hanging around" predominated as dolphins alternated between mating, randomly moving, and traveling in and out of the jetties. Upon several occasions, dolphins that randomly milled around the ends of the jetties abruptly approached a shrimp boat traveling towards Matagorda Bay. They rode the bow-wave several hundred meters into Matagorda Bay, abruptly departed from the boat, returned to the ends of the jetties, randomly moved about for a short period of time, and invariably approached another on-coming boat. On 5 June 1979, a pod of three dolphins and a second pod of two moved out of the jetties and suddenly veered off to approach a shrimp boat that was entering the jetties. As it passed, they began feeding in its wake. Other times, dolphins swam towards approaching shrimp boats that were still several hundred meters away and positioned themselves in the exact area where the boats eventually passed.

Towing the Trawl. Gunter (1954) and Norris and Prescott (1961) mentioned that Tursiops appeared to distinguish between the various sounds of the engine and winch signifying the stage at which the shrimp boat was operating. They stated that dolphins approached boats from long distances away when the trawl was lowered into the water as well as immediately before the trawl was hauled onto the back deck.

Similar observations in Matagorda Bay supported claims that the dolphins were well-versed in the routines of shrimping and appeared able to distinguish between steps of the procedure. The degree to which they were familiar with the shrimping process was especially evident by the way in which they followed the net up to the stern as it was hauled in, and then immediately continued forward to the far sides or bow of the boat to mill around, play, or nuzzle one another while the trawl was out of the water and the catch dumped on deck. The animals moved behind the stern and continued to follow the net again once the trawl was returned to the water. Other times, however, the dolphins would follow the net step by step as it approached the stern and would then rise far out of the water attempting to take fish directly from the cod-end of the trawl as it swung from the water onto the deck. During other instances, dolphins switched to nearby shrimp boats as the trawl was hauled in rather than wait for it to be returned to the water several minutes later. They immediately switched over to a towing shrimp boat if the original boat showed any signs of slowing down in order to "pick up" the trawl. Upon three occasions, several dolphins that had been consistently following the same boats for nearly 1 hour abruptly left them and began racing-diving to other boats, where they resumed feeding. Within seconds of their departures,the original shrimpers not only hauled in their trawls but immediately increased their speeds and headed towards town.

Simultaneously Towing the Trawl and Culling Out. Leatherwood (1975) and Shane (1977) and Shane and Schmidly (1978) distinguished two types of working shrimp boat-related feeding patterns in which dolphins (1) foraged behind working shrimp boats, presumably feeding on stirred-up live fish and organisms or picking gilled fish out of the net; and (2) closely approached the boats in order to feed on discarded trash fish. The dolphins' preference, if any, for one feeding type over the other, was not mentioned. Eighty-five complete tows were observed both from aboard the "Capt. Morocco" as well as from the project boat. In only one instance were the majority of dolphins congregated at the stern feeding on trash fish while the trawl was being towed. A pattern of actively following the net seemed preferable to merely feeding on cull up at the stern although the dolphins exhibited little fear of the boats. Following behind the boat may have been more desirable because it permitted the dolphins to feed on live, stirred-up fish, organisms, and gilled fish, as well as upon trash fish that had drifted back through the water from the stern after being discarded. By exclusively feeding upon trash fish, the dolphins would have been limited to predominantly dead fish and heavy competition with gulls and terns.

Idling, Drifting, or Anchored and Culling Out. *Tursiops* did closely approach the sterns and sides of shrimp boats in order to take trash fish after the boats ceased to tow their trawls. Shrimpers often threw fish directly to the dolphins that appeared to compete with the heavy concentrations of gulls (Hogan, 1975; Shane, 1977; Shane and Schmidly, 1978). Side and upside-down swimming was commonly observed (Leatherwood, 1975) and large bubbles (Caldwell and Caldwell, 1972b) welled up to the surface. Most fish were seized under water which was usually too turbid to permit identification of species or a detailed description of the dolphins' feeding methods. Although they were often observed daintily picking fish off the surface and taking them horizontally in their mouths before swallowing, dolphins were also observed lunging at trash fish.

Some shrimpers mentioned that they often hand-fed dolphins after the last tow. Although this was not seen, 10 to 15 dolphins which had been individually feeding on trash fish were observed crowding around the side or stern of a shrimp boat and bobbing up and down in the water as the shrimper tossed fish directly to them. Shrimpers sometimes stooped down on the edge of the back deck, and if the dolphins would not accept fish which were offered by hand, they would toss the fish which were caught in mid-air by the dolphins.

"Naturally Tagged" Dolphins and Shrimp Boats

Nine of the "naturally tagged" dolphins associated in some way with shrimp boats during the year. The majority were noted following behind boats that were actively towing trawls. In the cases of Ourania, Little Chopped, Pointed Finger, Gash, and Huckleberry, the locations in which they were sighted in association with the boats were also the most distant points at which they were ever observed.

Seasonal Movements

The extent and degree to which dolphins are attracted to the easily accessible food provided by shrimping operations is unknown. Although it was evident that the animals altered short-term movement or travel in order to approach trawling boats that were 1.0 to 1.5 km away, the maximum distance from which dolphins would purposely approach shrimp boats remained unclear. Also confusing were the large concentrations of Tursiops in regions that were virtually empty of dolphins when shrimp boats were not present. Periodic abundances of dolphins in Section 5 corresponded with the section's heavy use by shrimp boats. Sightings of the dolphins corresponded with the presence of bay and bait shrimpers in Section 5 from April until June harvesting brown shrimp (Penaeus aztecus) and from July to mid-October harvesting white shrimp (Penaeus setiferus). By the end of October, most of the fleet had moved several kilometers north and northeast towards the middle of Matagorda Bay, and towards the Matagorda Peninsula near the bulkhead. Section 5 estimated density declined, remained low for the following several months, and began to steadily increase in June. By August 1979, at the conclusion of the study, the section exhibited its highest density of the year. The increase of dolphins corresponded exactly with the resumption of shrimping in June, and the majority of dolphins were observed associating with shrimp boats as they had done there the previous summer. This is not meant to discount the possibility that increased numbers of dolphins in that area may have been due to the large-scale return of many fishes to the increasingly warmer Bay waters. Herds of dolphins northwest of the Port O'Connor jetties and along the shoreline towards Indianola Harbor were regularly observed feeding on trout (Cynoscion). The presence or absence of shrimp boats in Section 5 may have played no part in the general movement of dolphins that exploited the easily accessible food source provided by the boats because they were in the area anyway.

A decline in area dolphin density was noted in the spring. Although shrimpers constantly reported high numbers of dolphins 8 to 10 km north of the study area, that region was not regularly covered. It was not known whether the large spring dolphin counts were normally found in those areas, or if the seasonally high concentrations of shrimp, fish, and boats were responsible for a shift to the area. In a somewhat similar case, a study involving 16 species of seabirds known to feed off fishery discards near Gray's Harbor, Washington (Wahl and Heinemann, 1979), found that 10 species were significantly more abundant within 6 km of the fishing vessels than beyond that distance. With the exception of one of the species, the higher abundance near the vessels was assumed to be primarily due to the birds' attraction to the discards.

Activity Cycles

Shane (1977) and Shane and Schmidly (1978) found that time of day had the most marked effect upon traveling, mating, resting, and racing-diving. Feeding peaks occurred between 0700 h and 1000 h, and 1700 h and 2100 h, and mating was most prevalent between 1000 h and 1300 h. Saayman et al. (1973) found that mating behavior increased following the morning feeding peak. Similar trends were noted during this study in which serious, almost regimented feeding was noted for several hours in the morning, often followed by variable periods of mating activity.

Social Composition and Behavior

As in the case of general pod size throughout the study area, the mean pod size of dolphins associating with shrimp boats increased during the spring and summer. Herd sizes increased during the spring and summer, although this may have been a function of fewer boats. Although 15 to 25 dolphins were observed behind each of the few boats that were shrimping in Sections 3 and 5 prior to the August 1979 fall shrimping season, similarly large numbers were not observed once the season opened. Seventy-five to 100 boats were present in the area enclosed by the Ship Channel from Powderhorn Ranch to an area several kilometers northwest of Indianola. A total of 30 to 35 dolphins was found throughout the entire section, widely distributed among the boats in several small pods. It had been hypothesized that the extremely large numbers of dolphins present just prior to the opening of the fall season would further increase with the appearance of at least 75 more boats. This, however, did not occur.

Specific differences in group composition between dolphins associating with shrimp boats and those far from the proximity of the boats were not observed. In both cases, herds consisted of variously-sized animals, with some degree of segregation noted among large animals, juveniles, and female-calf pairs. Leatherwood (1977) reported calves of 7 to 10 months of age taking fish, although this was not observed in the present study. Pod and herd structure and stability remained unclear as both individuals and pods that appeared to belong to larger herds split away from one another in order to approach various boats. It was not determined whether pods that initially approached boats together also departed together because the animals often separated during the course of feeding. Saayman and Tayler (1973) described groups of humpback dolphins (Sousa) which met at feeding grounds and mingled to feed or interact, after which they combined and departed in compact traveling formations or regrouped into units different than their original compositions. Although the social cohesion among humpback dolphins seems looser and less structured than that of Tursiops, individual Tursiops rather than intact group units commonly switched among shrimp boats.

Gulf Shrimping

A total of 21 hours was spent observing dolphins associating with shrimp boats in the Gulf of Mexico. A noticeable increase over the frequency of leaps, racing-dives, and tail-slaps in Matagorda Bay was evident in the Gulf, and a large amount of energy seemed exerted on surface and aerial activity. Reasons behind these behavioral differences are not clear although similarly energetic behavior was also noted among near-shore Gulf dolphins when shrimp boats were absent.

The fact that several dolphins continued to follow an empty net that was mistakenly towed for 2 hours suggests that feeding on stirred-up fish and organisms is a worthwhile and important function of following the net. During the majority of cases in which the fish and shrimp do accumulate in the net, more time may be spent plucking gilled fish from the mesh rather than feeding exclusively on stirred-up fish. However, when this alternative did not exist, the amount of stirred-up fish and organisms was substantial enough to attract the dolphins for 2 hours.

Shrimper Questionnaire

The results of the shrimpers' questionnaire aided in better understanding the bay shrimp fishery's effects upon the ecology of _Tursiops_ in Matagorda Bay. Most of the shrimpers' observations corroborated those of the investigator and contributed subjective information concerning areas of dolphin abundance; recognizable animals; behavior during the approach, active following, and departure from boats; group composition; shark-dolphin interaction; trawl damage and food preference.

Widespread trawl damage blamed on dolphins was claimed to occur prior to 1961 when the trawls were constructed of cotton. Dolphins were commonly shot until shrimpers began to use trawls constructed of a nylon-cotton mix (ny-cot) in the early and middle 1960's. A dramatic decline in damage was supposedly noted. It is not known how widespread shooting is today. With one exception, all shrimpers who admitted to shooting dolphins (23% stated that they had shot at dolphins to scare them away, while 18% said they had deliberately killed dolphins) were over 45 years of age and had shrimped for more than 20 years. None of the 14 stranded _Tursiops_ found in or near the study area showed any indication of having been shot.

Although the investigator was aware of only one incident during the study in which a dolphin was found dead in a shrimp trawl, 77% of the shrimpers stated that they had never captured a dolphin during their years of shrimping. Although further investigations are necessary to determine whether shrimp trawls significantly contribute to dolphin mortality, available data suggest that the loss is relatively small.

Strandings

Species

Schmidly and Melcher (1974) reported that Tursiops truncatus was the most common delphinid in Texas waters, and Schmidly and Shane (1978) designated Tursiops as the most common cetacean in Texas inshore waters according to stranding records and observations. During this study, 65% of the strandings were positively identified as bottlenosed dolphins. Four other cetaceans, sighted from small aircraft, were reported as Tursiops but were not confirmed by the investigator. Assuming that these cetaceans are Tursiops, 78% of the strandings involved bottlenosed dolphins.

Schmidly and Shane (1978) noted that stranding data are not necessarily reflective of relative abundance among cetaceans. For example, Gunter (1954) claimed that spotted dolphins (Stenella plagiodon) were common in offshore waters of the Gulf of Mexico. According to the number of observations and recorded strandings, Schmidly and Shane (1978) considered the spotted dolphin the second most common cetacean in Texas waters, and possibly the most common species offshore. However, not a single stranding was reported during their stranding network operation from 1 January 1974 to 31 December 1975. The same circumstance held true during this study, in which no stenellids were found beached. The three stenellids listed as stranded during this study were actually harpooned several kilometers offshore of Port Isabel, Texas, to be used as shark bait. The number of other cases that occur unnoticed, undiscovered, or unreported may play a significant role in the mortality of Stenella plagiodon and other pelagic species of small cetaceans. American shrimpers who had worked off the coast of Mexico for several years stated that Mexican boats frequently harpooned dolphins for shark bait by closely approaching the American boats as dolphins followed the shrimp trawls (R. Duval, Jr., pers. comm.).

Other shrimpers mentioned the regularity with which they saw large herds of stenellids several kilometers off Matagorda Peninsula and Matagorda Island. Fishing guides and tourists have also remarked about the abundance of stenellids that approach their boats several kilometers offshore.

The January 1979 stranding of a female Blaineville's beaked whale (Mesoplodon densirostris) was the first recorded stranding of this species for the Texas coast and for the western Gulf of Mexico. It was also the first of several documented beaked whale strandings that occurred along the Texas coast between August 1979 and July 1980. As previously mentioned, one Gulf Stream beaked whale (Mesoplodon europaeus) was found southwest of Port Aransas on 31 August 1979. In February 1980 one M. europaeus was reported south of the ranger station at Padre Island National Seashore, and in July 1980 one goose-beaked whale (Ziphius cavirostris) was stranded near Port Isabel, Texas.

Location

Several of the strandings that occurred within 20 km of Pass Cavallo were concentrated in two relatively small areas. Three dolphins were found within a radius of 1.0 km of the intersection of the Intracoastal Waterway and the Army Cut. The two dolphins that were found on the Waterway shorelines may have drifted in through the Army Cut from Espiritu Santo Bay. Four Tursiops, including two newborn animals, beached 16, 18, and 20 km southwest of Pass Cavallo. The first newborn beached 16 km from the Pass in April 1979 and was transported to an enclosure several kilometers to the north where it could be more easily necropsied. Four months later, a second newborn stranded within 1 km of the first site. The two other dolphins which were found 2 and 4 km, respectively, from that area, beached in February and March 1979. No unique or unusual physiographic features were noted anywhere in the 4-km stretch in which the dolphins were found, but an unusually high number of Tursiops was counted milling around and traveling in that area during the November 1980 National Marine Fisheries Service (NMFS) aerial surveys.

Seasonal Occurrence

Definite seasonality in the occurrence of strandings was noted and 74% of the strandings were recorded during the winter and spring. Seventy-nine percent of all Tursiops strandings occurred during the winter and spring; 29% in the winter, and 50% during the spring. Schmidly and Melcher (1974), Schmidly and Shane (1978), Shane (1977), and Shane and Schmidly (1978) also concluded that seasonal variation in Tursiops strandings was evident since the majority of strandings which they investigated occurred during the winter and early spring. The more adverse weather conditions during the winter coupled with susceptibility to disease and parasites probably accounted for many of the strandings that were particularly evident during March 1979.

Sex

Five male and three female Tursiops were sexed. Shane (1977) and Shane and Schmidly (1978) found a greater proportion of males than females during their 1976-1977 study, and Schmidly and Shane (1978) found nine males and seven females among the Tursiops which they investigated during 1974-1975.

Age-Size Classes

Contrary to Layne's (1965) findings that a large proportion of strandings consisted of very young dolphins, the 14 Tursiops which were measured were fairly evenly represented among all four of Ridgway's (1968) age-size classes. Twenty-nine percent were less than 1 year old, 29% were between 1 and 3 years old, 21% were 3 to 6 years old, and 21% were over 6 years old. According to the limits prescribed by both Harrison and Ridgway (1971) and Sergeant et al. (1973), only one of the eight sexed _Tursiops_, a male, was sexually mature. Two other males both measured 243.84 cm in total length and were 1.16 cm shorter than the lower length of sexual maturity for males as given by Sergeant et al. (1973).

Possible Causes of Death

Causes of the deaths of the majority of strandings could not be determined. Several animals were inaccessible; some were badly decomposed; and others were dry and leathery and partially eaten, presumably by coyotes. The deaths of five and possibly six of the cetaceans were caused by humans. Three stenellids and one _Tursiops_ died as a result of being harpooned, one _Tursiops_ was badly cut by a boat propeller, and one _Tursiops_ possibly drowned in a shrimper's net. Three of the four newborn bottlenosed dolphins were found 2 to 3 days after "northers" (sudden, heavy northerly winds bringing about rough seas) had passed through the area. The navel of one of the newborns was possibly infected. The infection and additional stress brought about by the adverse weather conditions may have been responsible for its death. A male _Tursiops_ that measured 304.8 cm in total length was found immediately after Tropical Storm Amelia. It had no cuts or wounds and showed no signs of having struggled on the beach. Although its teeth were not worn down, the dolphin may have been quite old, possibly diseased, and was further debilitated by the storm. The _Tursiops_ which was found on 19 February 1979 had an extremely thin blubber layer and empty stomach. It appeared emaciated particularly in the region of the neck and may have suffered from a disease which left it without an appetite or incapable of feeding.

SUMMARY

1. The estimated population density in the Pass Cavallo area of Matagorda Bay, Texas, ranged from a high of 1.29 ± 0.161 *Tursiops*/km (98.16 dolphins) in February 1979 to a low of 0.396 ± 0.094 *Tursiops*/km^2 (30.08 dolphins) the following April. These monthly estimates were obtained by adding the individual section monthly counts of dolphins and dividing the total by the 75 km^2 study area. Significant correlations ($p < 0.0001$) between dolphin abundance and month, dolphin abundance and section, and dolphin abundance and the interaction of month and section were found.

2. Twenty dolphins were identified by their unique dorsal fins, scars, or otherwise recognizable characteristics. Most of the dolphins appeared to belong to one of three extended herds, each occupying its own herd range. Virtually no interaction among dolphins belonging to different extended herds was ever observed. Although the "natural tags" were consistently found in the same regions from one encounter to the next, sightings were too infrequent to discount the possibility that extensive home range-related movement outside the study area did occur.

3. Seasonal movement into and out of the study area and heavy seasonal utilization of particular regions over others was observed. Short-term movement patterns varied from seemingly "aimless", random movement and milling, to rapid, goal-oriented travel. Dolphin daily movements were significantly influenced by tidal flow and time of day.

4. A previously identified dolphin from an earlier study 95 km to the southwest in the Aransas Pass area of Texas (Shane, 1977; Shane and Schmidly, 1978) was sighted on 29 June 1979 in the near-shore Gulf 0.5 km from the study area. The chance observation raised questions regarding daily and long-term movement patterns, home range utilization, inshore-Gulf of Mexico interchange, and sociality of *Tursiops*.

5. Social bonds were characterized as fluid, dynamic, and changeable, as well as long-term and recurrent. Mean pod size (two to four

dolphins) and mean herd size (11 to 15 dolphins) remained fairly constant according to month, season, time of day, and depth, although significant differences at the 0.05 level were found between herd size and section. Calves constituted 7.21% of all Tursiops sighted during the year. Lowest calf percentage (5.07) occurred in December 1978, and the highest percentage (9.21) was recorded in June 1979.

6. Five major stages of shrimp boat operation and shrimp boat-related behavior and activities of Tursiops were defined. Seasonal movements, activity cycles, and sociality, as well as the association of "naturally tagged" dolphins with shrimp boats were described.

7. Results of a questionnaire distributed to shrimpers portrayed their generally positive attitudes towards bottlenosed dolphins and supplied additional, informal information regarding the multi-faceted relationship among shrimpers, dolphins, fish, and boats. At the present time, the bay shrimp fishery appears to play an insignificant role in dolphin mortality.

8. Three bottlenosed dolphins within a 45 km^2 region of the study area were infected with the fungal disease, Lobomycosis. These cases constitute the first reported incidents of the disease in the western Gulf of Mexico.

9. Four species, totalling 23 cetaceans and including four harpooned delphinids, were reported as stranded. Sixty-four percent of the strandings were found within a 20-km radius of Pass Cavallo. Strong seasonality of strandings was evident. Accessible animals were photographed, measured, and sexed, and stomach contents were collected whenever possible.

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APPENDIX A

SHRIMPER QUESTIONNAIRE

25 May 1979

Dear Shrimper:

During the course of the year, I've been lucky enough to talk to many of you about the porpoises that approach and follow your shrimp boats constantly. I realize that you're not out there studying porpoises and often don't even pay all that much attention to them. The detailed observations of porpoise groups and behavior and other interesting things that you have noticed have helped me see and understand the porpoises in a new way that would have been impossible without your help. I owe all of you a lot of thanks--you've taken an interest in what I'm doing, have offered to take me along when you go shrimping, have shared your attitudes about porpoises and shrimping with me, and, most of all, have accepted me and really made me feel a part of this place.

In order to gain an even clearer picture of the shrimp boat-porpoise association, I decided to make up a questionnaire that would cover the subject more fully. I hope you will take the time to fill it out. Thanks again.

Please return to the office at Clark's as soon as possible.

Yours,

Jody

1. Boat Name (not required) ________________________ Length ________
2. Check (√) type of boat: Bay _____ Bait _____ Gulf _____
   Bay, Bait, Gulf _____
   Bay, Bait _____
   Bay, Gulf _____
3. Net width ____________ Mesh size ____________
4. Please check (√) all areas where you drag during the year and state when.

Where | Time of Year

_____ Matagorda Ship Channel
_____ Mouth of Carancahua
_____ Middle of Matagorda Bay
_____ Off Matagorda Peninsula
_____ East End of Matagorda Bay
_____ Port O'Connor to Magnolia
_____ Lavaca Bay
_____ Espiritu Santo Bay
_____ San Antonio Bay
_____ Gulf Beach
_____ Gulf

5. Where do you see the most porpoises? How many? When?

6. Check (✓) which of the following influence the number of porpoises you see:

_____ Place or Area
_____ Time of Day
_____ Month or Season
_____ Sea State
_____ Weather
_____ Tide
_____ Depth
_____ Bay or Gulf
_____ Bottom Type
_____ Fish Life Cycles and Movements

7. How do the porpoises approach your boat during the first drag? Do they move quickly towards you? How long do you usually drag before you notice them? Do they approach in any particular arrangement or formation? From any particular direction?

8. Check (✓) which of the following statements is most accurate:

_____ Porpoises follow the net but do not approach the boat to eat trash fish thrown overboard.
_____ Porpoises approach the boat to eat trash fish thrown overboard but do not follow the net.
_____ Porpoises equally follow the net and approach the boat to eat trash fish thrown overboard.
_____ Porpoises seem to prefer to follow the net, and sometimes approach the boat to eat trash fish thrown overboard.
_____ Porpoises seem to prefer to approach the boat to eat trash fish and sometimes follow the net.
_____ Porpoises eat out of the sack as you pick up.

9. Do any of the porpoises recognize your boat? What makes you think so?

10. Do *you* recognize any of the porpoises? How?
Which animals do you remember? Please describe them and draw their dorsal fins. When and where did you see them?

11. Please check (√) the situations that you have seen.

_____ Same Porpoises/Same Area
_____ Same Porpoises/Different Area
_____ Different Porpoises/Same Area
_____ Different Porpoises/Different Area

12. What do the porpoises do when you are:

a. Tied up at the dock - no culling out?

b. Anchored up in the Bay or Gulf and culling out; or tied up at the dock culling out?

c. Underway to shrimping grounds at a relatively fast speed?

d. Putting net over?

e. Dragging (first drag and no culling out yet)?

f. Picking up net?

g. Dragging and culling out at the same time?

h. Drifting or idling and culling out?

i. Returning to dock after the last drag?

13. What do the porpoises do when you begin picking up until you put over and continue dragging again?

14. Please check (✓) which behaviors you have seen:

_____ Feeding
_____ Mating
_____ Playing (tossing fish, cabbageheads, "surfing")
_____ Leaping
_____ Bow-wave Riding
_____ Short-diving (porpoise surfaces, blows, and dives exposing only its blowhole and dorsal fin)
_____ Long-diving (porpoise arches back after breathing and exposes its tailstock as it dives)
_____ Flukes-up diving (similar to long-diving but tail is raised in air as the porpoise dives)
_____ Racing-diving (low, fairly horizontal dives with entire back and fin exposed -- porpoise makes rapid forward progress)
_____ Tail-Slapping
_____ Tail-Walking
_____ Coughing (loud, expulsive breath)
_____ Conference (group at surface with fins and often foreheads and backs exposed for several seconds with beaks towards each other in tight circle or semi-circle)
_____ Spy Hop (poking head and upper part of body out of water and slowly sinking down)
_____ Changing back and forth among shrimp boats

15. Which behaviors do you see most frequently?

Where?

When?

16. Please check (✓) which of the following influence the behaviors you have seen:

_____ Place or Area
_____ Month or Season
_____ Weather
_____ Depth
_____ Bottom Type
_____ Time of Day
_____ Sea State
_____ Tide
_____ Bay or Gulf
_____ Fish Life Cycles and Movements

17. What kind of group composition have you noticed? Is there any type of formation or arrangement among the porpoises? What sizes of porpoises do you notice together? Do you see mothers and calves? Do you see single, lone porpoises?

18. Have you ever seen porpoises fight with other porpoises? What were they doing? Do certain porpoises get the best "spot"?

19. Have you seen porpoises and sharks feeding together? Have you ever seen them fight?

20. Do porpoises damage your nets? Explain why you think so.

21. Are porpoises a general nuisance around your boats? Have you ever shot at a porpoise to scare it away? Have you ever shot at a porpoise to kill it?

22. Do porpoises show any fear of you, your boat, your net, or the noise?

23. Have you ever caught a porpoise in your net?

24. What differences have you noticed between bay porpoises and the same gray porpoises you see in the Gulf? (Differences in behavior, aggression, in the way they feed, group size and structure.)

25. Have you seen spotted porpoises in the Gulf?

Have you seen mixed groups of spotted porpoises and the gray porpoises you normally see in the Bay?

26. If a lot of porpoises are found where shrimp boats are dragging, do you think they were already in the same general area, or did they purposely come from several miles away?

Do you think the shrimping seasons and certain times of year when there are a lot of shrimp boats in the Bay affect the movements and general locations of porpoises?

27. How big a part does the porpoise's attraction to shrimp boats play in its "daily life"?

28. Do porpoises migrate in and out of the Gulf, or up and down along the coast, or to different areas of the Bay? Do they stay in the same general areas all year round?

29. Please list the most common fish that get caught in the net. Which fish do the porpoises seem to prefer?

During the year, what changes do you see in the number and kinds of trash fish you get?

Do the number and kinds of trash fish relate to the number of porpoises and their behavior?

VITA

Jody Ann Gruber, daughter of Haskell and Rosalind Gruber, was born on 11 May 1951 in Brooklyn, New York. She attended several elementary and secondary schools in the United States and in Germany, and was graduated from Thomas Jefferson High School, San Antonio, Texas, in 1969.

Undergraduate work in Psychology/Social Work was undertaken at the University of Texas at Austin, Tel Aviv University (Tel Aviv, Israel), and Hebrew University (Jerusalem, Israel). She concurrently worked as a Social Work Intern at the Lod Social Welfare Department (Lod, Israel), and at the Children's Psychiatric Unit, Austin State Hospital (Austin, Texas), receiving her Bachelor of Arts Degree in 1973. After a period of work and wildlife-oriented travel in the western United States, throughout Europe, and in parts of the Middle East, the author began graduate work at Texas A&M University in 1977.

While working on the Master of Science degree, the author participated in a National Marine Fisheries Service (NMFS)/Hubbs Sea World Research Institute Bottlenosed Dolphin Project in Melbourne, Florida, as well as in NMFS dolphin aerial surveys based in Rockport, Texas. Since the conclusion of her fieldwork in Matagorda Bay, Texas, she has conducted boat and shore-based follow-up observations in that area as well as preliminary interviews and ship-board observations in Galveston Bay, Texas. She has attended several seminars, scientific meetings, and technical sessions, and has presented papers on various subjects relating to *Tursiops truncatus*.

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The typist for this thesis was Dorothy Holtkamp.