Biological Services Program

FWS/OBS - 81/36
September 1981

Pilot Study of the Marine Mammals, Birds and Turtles in OCS Areas of the Gulf of Mexico

Bureau of Land Management
Fish and Wildlife Service

U.S. Department of the Interior

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues that impact fish and wildlife resources and their supporting ecosystems. The mission of the program is as follows:

- To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.

- To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major changes in land and water use.

- To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decisionmaking process to prevent or minimize the impact of development on fish and wildlife. Research activities and technical assistance services are based on an analysis of the issues, a determination of the decisionmakers involved and their information needs, and an evaluation of the state of the art to identify information gaps and to determine priorities. This is a strategy that will ensure that the products produced and disseminated are timely and useful.

Projects have been initiated in the follcwing areas: coal extraction and conversion; power plants; geothermal, mineral and oil shale development; water resource analysis, including stream alterations and western water allocation; coastal ecosystems and Outer Continental Shelf development; and systems inventory, including National Wetland Inventory, habitat classification and analysis, and information transfer.

The Biological Services Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams, which provide the Program's central scientific and technical expertise and arrange for contracting biological services studies with states, universities, consulting firms, and others; Regional Staffs, who provide a link to problems at the operating level; and staffs at certain Fish and Wildlife Service research facilities, who conduct in-house research studies.

FWS/OBS - 81/36
September 1981

PILOT STUDY OF THE MARINE MAMMALS, BIRDS AND TURTLES IN OCS AREAS OF THE GULF OF MEXICO

by

Thomas H. Fritts and Robert P. Reynolds
U.S. Fish and Wildlife Service
Denver Wildlife Research Center
New Orleans Field Station
Tulane University Museum of Natural History
Belle Chasse, Louisiana 70037

Contract No. 14-16-009-79-951

Project Officers
Cherry E. Keller
David M. Smith
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service

This project was sponsored by the
Bureau of Land Management

Prepared for
Coastal Ecosystems Project
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
Washington, D.C. 20240

SUMMARY

Aerial surveys of marine mammals, birds, and turtles were conducted at four subunits of the Gulf of Mexico from August to December 1979. This Pilot Study was designed to develop techniques and to collect preliminary data on the vertebrate faunas of outer continental shelf (OCS) waters. This information, once expanded to include an adequate sample size, will be important to evaluating effects of oil and gas development in offshore areas.

Surveys were conducted at altitudes of 91 and 228 m. The 91-m surveys were superior for detecting and identifying birds and turtles, while more area could be surveyed for larger animals at 228 m. Waters within 111 km of shore were sampled at a 3:1 ratio in relation to waters 111 to 222 km offshore. Texas subunits extended beyond the continental shelf, but Florida subunits did not. Observations were made on 12 mammal, 35 bird, and 5 turtle taxa. Sperm whales were documented in waters off Texas. Marine turtles were common in the eastern Gulf but virtually absent from the western areas studied. Differences in dolphin faunas in the eastern and western subunits were noted and potential north-south movements in response to season were noted on both sides of the Gulf of Mexico.

The maps and basic ecological data collected provided a unique view of faunal differences within OCS areas of the Gulf of Mexico. Because of the complexity of the Gulf of Mexico and its fauna, additional analyses will depend upon having data encompassing annual, seasonal, geographic, and bathymetric variation.

Additional survey areas and more frequent samples emphasizing seasonal variation on successive years are required for making more accurate conclusions and effective management decisions relevant to OCS development.

CONTENTS

CONTENTS Concluded

FIGURES

TABLES

TABLES Continued

TABLES Continued

TABLES Concluded

ACKNOWLEDGMENTS

Field work was conducted by personnel of the Denver Wildlife Research Center and Texas A & M University. Larry Hobbs, Stephen Leatherwood, and Charles Gates contributed to the development of the study plan. Linda S. Dunn contributed technical assistance and Joan Randell typed the manuscript.

INTRODUCTION

The Marine Mammal Protection Act (MMPA) of 1972 (16 U. S. C. 1361-1407) recognized the importance of marine mammals and established a national policy designed to protect marine mammals and the habitats in which they occur. The Endangered Species Act of 1973 provided for the conservation of all plant and animal species that are determined to be endangered or threatened. Implementation of both acts has pointed out the complexity of biological systems and the need for information about organisms and their environments to provide a basis for management decisions relating to man's utilization of the environment.

To make effective management decisions relative to oil and gas exploration and production on the Outer Continental Shelf (OCS), the Bureau of Land Management requires information on the distribution and abundance of organisms that are potentially affected or vulnerable to activities in the OCS area. Thirty-two species of marine mammals protected by the MMPA, including six endangered species, occur within the South Atlantic and Gulf of Mexico OCS area. However, even the most basic aspects of their biology within the area are poorly understood because of the lack of thorough studies involving systematic and modern sampling regimes. Similarly, five species of marine turtles are present, including four that are considered endangered within the area. Since the Gulf of Mexico and South Atlantic waters are the warmest waters coterminous with the United States, they contain the most significant sea turtle populations within national limits and border on all significant nesting beaches in the United States, with the exception of Hawaii and Puerto Rico.

The birds of this area include several endangered species in coastal areas, but also include key pelagic species. The abundance of these important oceanic migrants reflects biological productivity and ecological relationships which are difficult and expensive to measure directly. Thus, oceanic birds are an important data source.

In order to minimize the impact of the development of energy resources in OCS areas, baseline data are needed for birds, marine mammals, and turtles in marine and coastal areas. Once species composition and abundance are known and key biological areas are specified, more precise studies will be needed to address major data gaps, potential problems with OCS activities, and the management procedure necessary to minimize critical environmental alterations (Figure 1). These objectives are contingent upon a firmly based survey expanding our present knowledge of birds, mammals, and turtles within the study area.

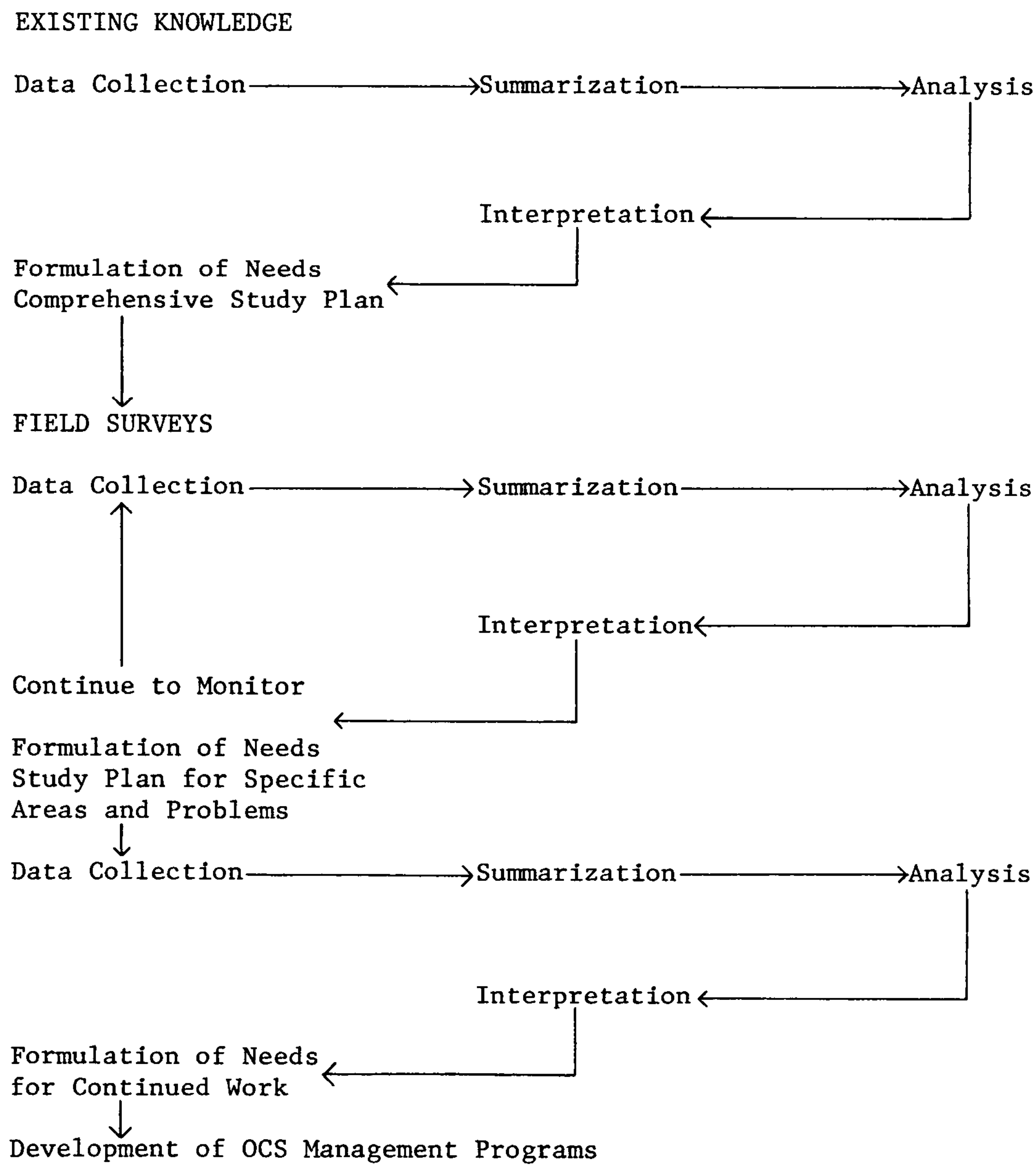


Figure 1. Overall study sequence for evaluating effects of OCS development on marine mammals, birds, and turtles.

A pilot study of the seasonal distribution and abundance of marine mammals, birds, and turtles in the Gulf of Mexico was initiated in June 1979. This study encompassed the initial steps of a comprehensive study of OCS effects upon these taxa. A comprehensive study plan was developed, and a variety of preliminary activities was undertaken. These included summarization of existing knowledge, review of the literature, development of software, development of survey techniques, and collection of preliminary data.

The objectives of the Comprehensive Study Plan were as follows:

1. To determine and confirm which species of marine mammals, birds, and turtles inhabit or migrate through the OCS areas of the South Atlantic and Gulf of Mexico;

2. To identify temporal and spatial distribution of these species and the patterns of movement associated with such distributions;

3. To identify, delineate, and describe any areas of special biological significance for feeding, migration, and maintenance of the populations encountered;

4. To provide a basis for estimating relative abundance of individual species within the study area;

5. To amplify the understanding of population structure and basic ecology of poorly known species or populations where possible; and,

6. To formulate specific questions and investigative lines for subsequent research relevant to effects of oil and gas development and other research priorities in OCS areas on mammal, bird, and turtle faunas.

The objectives of the Pilot Study were as follows:

1. To develop and test methods suitable for simultaneously surveying marine mammals, birds, and turtles from aircraft.

2. To develop and test with real and simulated data, the computer software necessary for analysis and storage of survey data.

3. To collect preliminary data on the distribution and abundance of marine mammals, turtles, and birds in the study area.

4. To summarize existing knowledge and literature on the marine mammals of the Southeastern United States.

5. To survey manatee distribution in southwestern Florida.

The present report presents the results of activities relative to objectives 1 through 3 of the Pilot Study. The methods section describes the survey techniques and analytical procedures developed. The results section provides detailed analyses of the preliminary data collected. Schmidly (1981) is publishing the review of marine mammal literature and data. The study of manatee distribution is contained in a separate report (Irvine et al. In press).

Work was coordinated from the New Orleans Field Station of the Denver Wildlife Research Center (DWRC; formerly National Fish and Wildlife Laboratory, NFWL) on the Riverside Campus of Tulane University. Personnel and resources of DWRC laboratories in Gainesville, Florida., Washington, D. C., and Albuquerque, New Mexico, were also involved in the study. Arrangements were made with Texas A & M University for participation of other scientists with expertise in marine mammals and for statistical analysis of animal abundance.

STUDY AREA

The Pilot Study aerial surveys were conducted entirely within the U.S. waters of the Gulf of Mexico. The Gulf of Mexico is a contiguous embayment of the north Atlantic Ocean encompassing some 1,640,000 km^2. Bordered largely by the United States, Mexico, and Cuba; its two main avenues of water exchange are the Yucatan and Florida submarine channels.

The continental shelf is variable in width but most of the coastline is characterized as having an extensive shelf. Widths vary from 185 km and 215 km off the West Florida and Yucatan coasts, respectively, narrowing to 25 km off the Rio Grande Outlet and 13 km near Vera Cruz, Mexico (Lynch 1954). The transition from a wide to narrow shelf is rather abrupt west of Campeche, Mexico, and southwest from approximately Galveston, Texas. The Desoto Canyon briefly interrupts the wide shelf off the panhandle region of Florida.

Currents are complex in origin but the basic pattern is analogous to that of the North Atlantic (Sturges and Blaha 1976). External input is largely from the Caribbean via the Yucatan Channel. Output is largely through the Florida Channel which contributes to the Gulf Stream. The micro-tidal range and the dominance of diurnal components (Marmer 1954) result in an increased importance of meteorologic forces on water circulation.

Two dominant meteorologic regimes characterize the region: the Bermuda High and mid latitude frontal passages. The Bermuda High dominates the area with wind speeds generally being the strongest during the summer months when the climatologic equator reaches its northern limits. Surface water temperatures are typically uniform over the Gulf of Mexico at this time, averaging some 28^{o} C over the continental shelf and slightly cooler over the central Gulf of Mexico (Leipper 1954). During winter, gradations of surface water temperatures are more conspicuous. Temperatures generally range from 18.5^{o} C in the northern Gulf of Mexico to 25^{o} C off the Yucatan Peninsula (Leipper 1954), reflecting the increasing influence of mid latitude frontal passages followed by cooler polar air. Tropical disturbances, of which hurricanes are the most intense, form a third weather regime. Although infrequent, these disturbances often result in dramatic environmental alterations.

There is an appreciable difference in the extent of human activities along the Florida and Texas coasts. The offshore oil activities and associated tanker traffic, along with the shrimp industry, are more intense along the Texas coast than off Florida.

In both Florida and Texas, the northern survey subunits described in this report occur in the vicinity of major shipping lanes and receive more commerical ship traffic than the southern subunits. Pleasure craft and sport fishing boats are common in both Florida and Texas waters.

METHODS

The methods utilized can be viewed in relation to the first three objectives of the Pilot Study. Objective one requires survey procedures generally applicable to the study of marine mammals, birds, and turtles. Objective two involves data management and analysis, and objective three requires methodological details specific to the preliminary surveys.

OBJECTIVE ONE: GENERAL SURVEY PROCEDURES

Survey Design

The survey design was based on a replicate model allowing the collection of a hierarchical data set which could be analyzed in a variety of ways. It was developed for the Pilot Study in consultation with Mr. Stephen Leatherwood of Hubbs-Sea World Research Institute. The design reduces sampling bias and "dead time" (travel to and from sampling units) between transects while enhancing statistical reliability and identification of environmental correlates. It is also suited to a large and complex study area such as the OCS areas of the southern United States.

Individual subunits with borders of approximately 111 km (60 nmi) on the shoreline and extending 222 km (120 nmi) perpendicular to the shoreline were sampled using transect legs 111 and 222 km long. Six legs were flown per day at intervals of 18 km (10 nmi) and parallel to the long axis of the subunit. Replicates were flown on two successive days resulting in a total of 18 transects (total survey length 2,664 km per subunit). Transects were randomized with regard to (1) sampling order, (2) subunit section (north or south boundary), (3) exact starting position, (4) flight altitude (91 and 228 m), and (5) observer position within the aircraft. Transect lengths of 111 and 222 km were used in a 2:1 ratio, but aircraft altitudes of 91 and 228 m were flown with equal frequency. A hypothetical subunit depicting the flight path for one day is shown in Figure 2. Aircraft ground speed was constant at 222 km per hour (120 kn). Flights began at approximately 0800 hrs. and were terminated if the sea state conditions reached a Beaufort 4 or higher. A minimum of 6 hours per day was required to complete six transects.

Weather conditions posed a particularly difficult problem in marine censusing, and not all surveys could be conducted under optimum conditions. Solar glare and rough seas were two problems for which no suitable solutions have been advanced. At Beaufort 4 large waves and numerous whitecaps impaired visibility by creating a visual distraction.

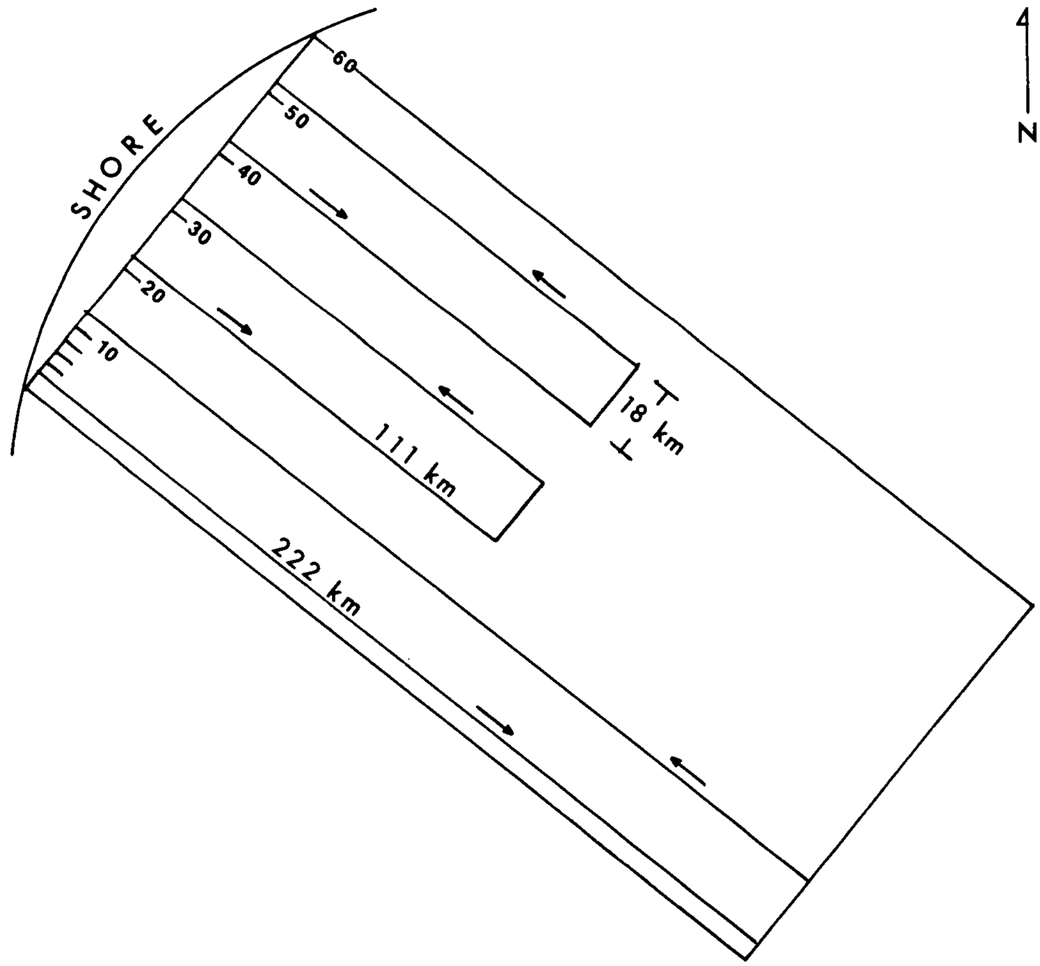


Figure 2. A hypothetical subunit depicting one day's flight path. On this day, it was randomly determined that (1) sampling would start at the southern boundary, (2) sampling would begin at nautical mile number 2, (3) the first leg would be 222 km (120 nmi) in length, and (4) the first leg would be flown at an altitude of 228 m (750 ft). The starting point and beginning altitude for replicate days would also be randomly chosen, but the order of long and short transect legs would change systematically to insure that 222 km transects were conducted in all possible positions in the subunit. On all days, altitudinal coverage was amplified by flying at 91 m (300 ft) on one leg of each round trip and at 228 m (750 ft) on the other.

The flight crew consisted of a pilot, data recorder, and two observers. Observers were positioned on each side of the rear of the aircraft, while the pilot and recorder manned the front seats. The data recorder also served as flight leader and was responsible for flight details. Observer position was switched after 222 km of transect flight. The following DWRC personnel participated as observers and/or recorders during the Pilot Study: John Caffin, Thomas H. Fritts, Larry Hobbs, Wayne Hoffman, A. Blair Irvine, and Robert P. Reynolds. Barbara Dorf and David Schmidly of Texas A & M University also participated as observer/recorders. The observer/recorder seating arrangement described was best for our purposes but should be adapted to the configuration of the plane.

Data Collection

While on transect, observers searched continuously. Upon making an observation, the observer relayed the information to the data recorder. The data recorded at each encounter included local time, distance from transect line (radial and perpendicular angles of observation using degrees marked on the wing struts and clinometers), species identification (to the lowest taxon possible), position of sighting (latitude and longitude from Loran C navigation system), group size, direction of movement, activity, and human activities. Flight characteristics and environmental data were recorded at the start of each flight and when changes occurred during the flight. Sea surface temperatures were measured with a radiometer and recorded. Data were recorded with both handwritten and verbal notes (cassette recorders). An example aerial survey observation sheet is shown in Figure 3. Data were reviewed and verified by the flight crew following each day's flight and subsequently transferred to computer compatible format for analysis. Figure 4 summarizes data flow for the field surveys.

Generally, whenever mammals or turtles were sighted, the aircraft diverted to the sighting and circled for closer inspection. This was not practical for birds because of their mobility.

In addition to marine mammals, birds, and turtles, sightings were recorded for fish, sharks, sargassum, oil, debris, oil platforms, and boats.

When possible, vertical and oblique photographs were taken of observations and indexed to actual time and date of observation.

Environmental Parameters

Two important variables that potentially influence the distributions of animals in oceanic waters are water depth and distance from shore. These variables are correlated but obvious differences do occur within the subunits surveyed during the present study. Therefore, an attempt was made to separate the effect of depth and distance. Visual representations of bathymetric variation have been constructed on the same scales as maps. Diagrammatic representations of shoreline configurations were also compared to the distributional patterns observed.

Surface water temperatures were measured using a Barnes PRT-5 radiometer onboard the aircraft at the time of the individual observations. These data are remarkably uniform. Analyses of surface water temperatures are presented in the results.

Survey #

Recorder

Obs. Pos. RR__ LR__

Page__ of __

Time	Lat/Long (TD_1/TD_2)	Species Group Size Best,Hi, Low Age	Radial Angle	Perpendicular Angle	Sighting Angle	Altitude Ground Speed	Aircraft Course °mag	Aerial Survey Observation Sheet Leg # / Dir.of Movement / Notes Beaufort Force / Sighting Dist. / Tape Air Temperature / Group Formation / Photo # Weather / On/Off Course / ID Cues Water Color / Associated sp. / Behavior Alt. of Bird / Reliability of ID Wind Speed / Debris / Barometer	Percent Clouds	Water Temperature	Glare S,M,B	Visibility NM-R,F,H

Figure 3. Example of an aerial survey observation sheet used during the Pilot Study.

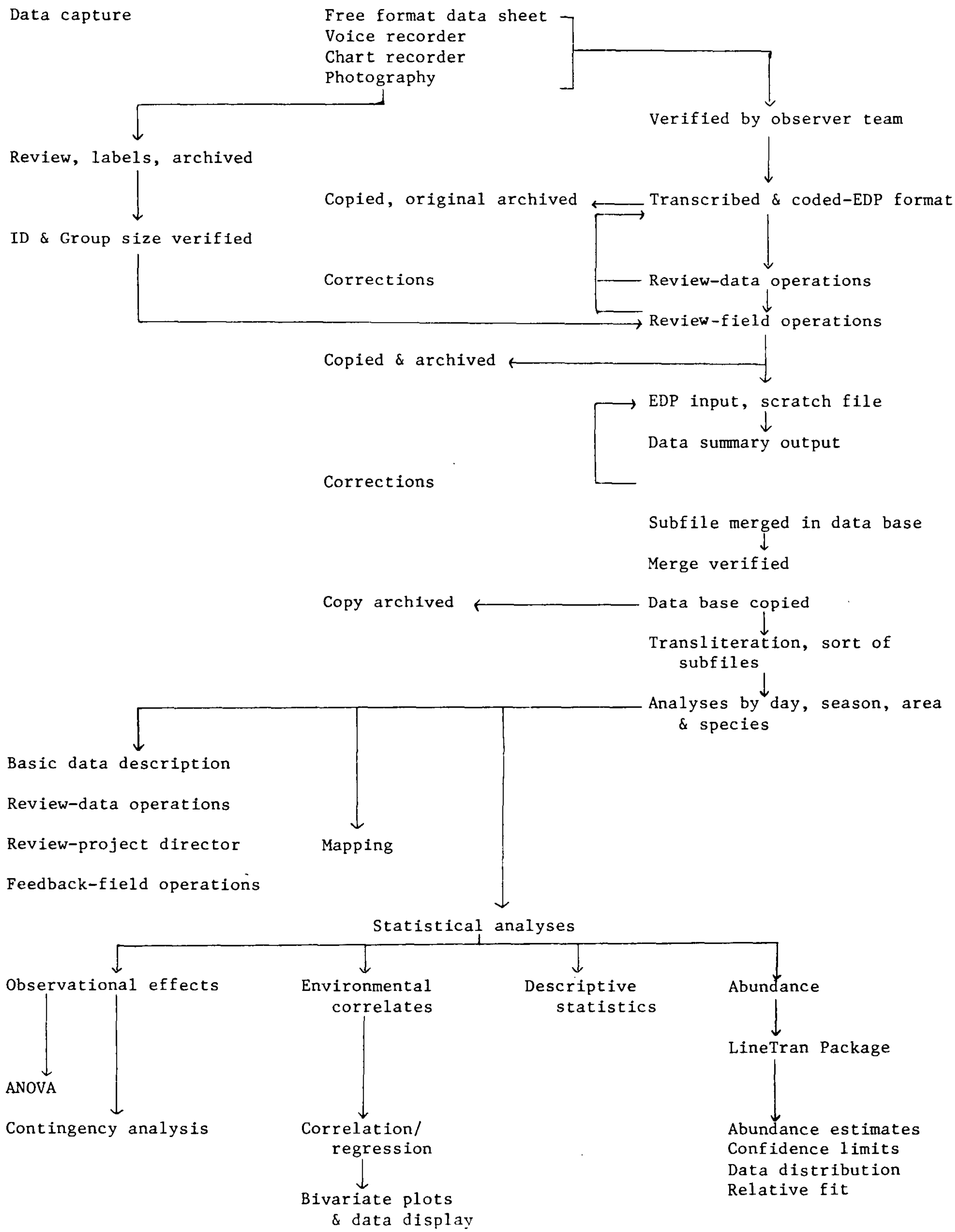


Figure 4. Data flow for the field surveys.

The distribution of three types of nautical craft was considered in the study. These are sport (recreational) craft, fishing/shrimp boats, and ships (including all large vessels not engaged in fishing or sport activities).

Two levels of association between different animal taxa were considered: (1) Incidental association resulting from sharing physical habitat such as inshore waters or perching sites, and (2) direct associations where interactions of various taxa are expected or where animals are responding to a shared resource such as krill, bait fish, and carrion.

OBJECTIVE TWO: DATA MANAGEMENT

Data Manipulation and Analysis

The identification, development, and testing of software necessary to capture, analyze, and archive field data relevant to the study are important elements of the Pilot Study. The Statistical Package for the Social Sciences (SPSS), an information management system with adequate flexibility for input, modification, analysis, and storage of a large data source, was employed in this project. SPSS offers a powerful combination of data input and data modification subroutines with potential for entry into a spectrum of internal or external statistical programs.

Data from all surveys were transcribed into a computer compatible format and entered into a data bank in the DEC-20 computer system at Tulane University, New Orleans, Louisiana. Transliteration was performed to standardize units of measure in the metric system and to facilitate data analysis. Latitude and longitude for each observation were stored as decimal equivalents of degrees in place of degrees and minutes as used on charts and maps. Species and other taxonomic groups were identified with a four letter alphanumeric code and a four digit numeric code which facilitated grouping and sorting of observations. The altitude of the aircraft, the group speed, and the water depth at the position were recorded in feet, knots, and fathoms, and subsequently converted to meters, kilometers per hour, and meters, respectively.

Population Enumerators

The investigation of marine animal abundance is fraught with numerous problems concerning the quantification of data due to the complexities of the living world. Although estimates of animal abundance are often imprecise, they provide a relative estimate of abundance that can answer a broad range of ecological and management questions to an acceptable level of approximation.

In the present study a combination of strip and line transect population enumerators was used to analyze data. Because of the diversity of methods for estimating animal abundance using line and strip transect methods and the need to compare the results of varied methods, a computer program capable of calculating the various estimates using the basic data input was needed. Linetran, the computer program chosen for data analysis, was developed by Professor Charles E. Gates at Texas A & M University. As no single estimator is best under all conditions, Linetran uses up to 14 different estimators to compute abundance. Linetran is very flexible and will handle right angle (perpendicular) distance and radial (sighting) distance in any combination. This program can provide a variety of parametric or non-parametric estimates depending on the normality of the data. This is an extremely important attribute as parametric estimates are highly dependent on underlying assumptions.

Analysis of population abundance has been completed at the Texas A & M Computer Center and the results are presented later in this report.

Mapping

As a preliminary aid to interpretation of the distribution and frequency of sightings, schematic maps (presented in the Appendix) have been plotted for selected species in each of the survey subunits. In these maps latitude and longitude of individual sightings are plotted on the vertical and horizontal axes, respectively. Positions are expressed as decimal equivalents of degrees rather than the degrees and minutes normally used in nautical mapping: for example, $82^{\circ}15'$ N is plotted as 82.25° N. In areas where two or more asterisks would potentially be plotted, the number of data points to be represented is used instead of the asterisks. Each diagrammatic map represents an area 111 x 222 km (60 x 120 nmi), and in some cases a slightly larger area including the survey subunit and adjacent areas necessary to form a rectangle with sides approximately parallel to lines of latitude and longitude.

For the SFLA survey subunit, a rectangle 111 x 222 km with an area of 24,730 km^2, the diagrammatic maps are accurate representations of the area surveyed. For NFLA and STEX, maps are approximate representations of areas 266 and 245 km in length which include a parallelogram with a length of 222 km and an altitude of 111 km equivalent to the survey subunit. Therefore, the NFLA maps include an area of approximately 2,550 km^2 that is outside the actual survey subunit, and the STEX maps include 4,928 km^2 not within the actual survey subunit. The actual area of maps used to depict the NTEX survey subunit encompasses 47,777 km^2, an area 23,047 km^2 larger than the survey subunit.

OBJECTIVE THREE: THE PRELIMINARY SURVEY

Training Session

An observer team was assembled and trained for aerial surveys in the Gulf of Mexico. Orientation flights and training sessions were conducted 20-23 July 1979 for testing of equipment, development of data recording sheets, standardization of observation techniques, and familiarization with the aircraft and navigational equipment.

Personnel were subjected to an intensive training session using selected training aids with an emphasis on field identification. Color slides of the marine mammals, birds, and turtles in the study area were studied along with field guides. Color slides were taken under field conditions and allowed observers to study the type of sightings they were likely to encounter while on survey. An important aspect of preparation was training observers to make consistent estimates by having them estimate the number of animals in a series of color slides projected for brief intervals. Copies of slides and field guides were made available to all workers for maintaining observation proficiency.

Offshore training flights were conducted to familiarize observers with the plane, navigational equipment, and survey mechanics.

Survey Subunits

Four offshore survey subunits were established in the vicinity of the following locations: Brownsville, Texas (STEX); Corpus Christi, Texas (NTEX); Tampa Bay, Florida (NFLA); and Naples, Florida (SFLA). Map 1 shows the approximate locations of the subunits; the precise subunit boundaries are listed in Table 1. Subunit deliniation was not restricted to specific bathymetric limits because of the extreme mobility of marine organisms, and the paucity of existing information precluded determination of definite depth correlates for marine mammals, birds, and turtles. Provision was made, however, for surveying subunits to depths exceeding 200 m and, in some areas, to much greater depths. Subunits were positioned so as to provide coverage on the eastern and western extremes of the Gulf of Mexico. The total area encompassed by the four survey subunits was 98,568 km^2.

Survey Dates

Dedicated aerial surveys were conducted from August to December 1979. Surveys were conducted during 5 to 10 August at the Florida subunits and in Texas from 20 to 25 August. No delays due to inclement weather were encountered in August. During the November/December flights, numerous cold fronts from the north created foul surveying conditions in the Gulf of Mexico, and flights were delayed considerably. During this period the Florida subunits were surveyed from 4 to 17 November, and the Texas subunits surveyed between 19 November and 4 December. Table 2 lists a detailed breakdown of survey dates.

Personnel at the National Oceanic and Atmospheric Administration (NOAA) Weather Service at Corpus Christi International Airport, Texas, informed us that inclement weather we encountered in the Gulf of Mexico during November/December was typical of the winter months. Future surveys should be scheduled accordingly.

Aircraft and Equipment

Aero-Marine Survey, Inc., a company with experience in marine survey work, was contracted for the tenure of the Pilot Study. The Cessna 337 Skymaster, used to fly the surveys, was equipped with extended-range fuel tanks, STOL kit for slow flight, TDL 711 Loran C radio navigation, surface and weather radar, radar altimeter, and an infrared radiometer for monitoring sea surface temperatures. The additional fuel capacity enabled the plane to carry 2 hours of extra fuel for emergency use. A voice-actuated intercom system was used during the November surveys, but not in August. The use of this equipment greatly facilitated data transfer from observers to the recorder.

Safety equipment aboard the plane consisted of a self-inflating life raft with attached radio beacon, Mae West style life preservers, and an emergency first aid kit.

Vertical photographs were taken with a built-in Hasselblad MK-70 camera with 70-mm wide angle lens. A 35-mm SLR camera with 200-mm telephoto lens was used for oblique photos.

Table 1. Coordinates of the geographic limits of each survey subunit. Coordinates are followed by their decimal equivalents enclosed in parentheses. Each quadrat is approximately 24,730 km^2.

Survey subunit	Geographic limits			
	NE	NW	SE	SW
South Texas (STEX)	27°01.5'(27.02°)N	27°01.5'(27.02°)N	26°01.8'(26.03°)N	26°02.4'(26.04°)N
	95°09.2'(95.15°)W	97°22.4'(97.37°)W	94°56.0'(94.93°)W	97°09.3'(97.15°)W
North Texas (NTEX)	27°47.5'(27.79°)N	28°26.4'(28.44°)N	27°00.8'(27.01°)N	27°39.0'(27.65°)N
	94°09.5'(94.16°)W	96°17.0'(96.28°)W	95°04.0'(95.07°)W	97°10.9'(97.18°)W
North Florida (NFLA)	28°00.0'(28.00°)N	28°00.0'(28.00°)N	27°00.0'(27.00°)N	27°00.0'(27.00°)N
	82°52.0'(82.87°)W	85°05.0'(85.08°)W	82°24.0'(82.40°)W	84°40.9'(84.68°)W
South Florida (SFLA)	26°10.5'(26.17°)N	26°10.5'(26.17°)N	25°10.5'(25.17°)N	25°10.9'(25.18°)N
	81°43.4'(81.72°)W	83°53.7'(83.89°)W	81°43.4'(81.72°)W	83°55.3'(83.92°)W

Table 2. Summary of dedicated aerial surveys conducted during the Pilot Study. The flight order describes the sequence of short (S) flights of 111 km one way and long (L) flights of 222 km one way. The initial altitude, starting point, and mile number are randomized factors which establish a sequential pattern for each day's flights.

Date	Survey subunit	Start time	End time	Flight order	Initial altitude (m)	Start point	Mile
Aug. 5	SFLA	0948	1431	S,S,L	228	North	4
Aug. 6	SFLA	0935	1519	L,S,S	91	North	9
Aug. 7	SFLA	0904	1343	S,L,S	91	North	7
Aug. 8	NFLA	1019	1525	S,S,L	228	South	3
Aug. 9	NFLA	0836	1451	L,S,S	91	South	3
Aug. 10	NFLA	0916	1524	S,L,S	228	South	7
Aug. 20	STEX	0928	1448	L,S,S	228	South	7
Aug. 21	STEX	0831	1440	S,S,L	91	South	6
Aug. 22	STEX	0812	1217	S,L,-	91	South	7
Aug. 23	NTEX	0759	1656	L,S,S	228	South	9
Aug. 24	NTEX	0758	1321	S,L,S	91	North	8
Aug. 25	NTEX	0815	1306	S,S,L	91	South	3
Nov. 4	SFLA	0824	Survey not completed due to inclement weather				
Nov. 5	SFLA	0705	Survey not completed due to inclement weather				
Nov. 6	SFLA	0712	Survey not completed due to inclement weather				
Nov. 7	SFLA	0826	Survey not completed due to inclement weather				
Nov. 8	SFLA	0800	1248	L,S,S	228	North	1
Nov. 9	SFLA	0816	1304	S,L,S	91	North	7
Nov. 10	SFLA	0808	1324	S,S,L	228	North	2
Nov. 11	NFLA	0850	Survey not completed due to inclement weather				
Nov. 12	NFLA	0843	Survey not completed due to inclement weather				
Nov. 14	NFLA	0720	Survey not completed due to inclement weather				
Nov. 15	NFLA	1125	1612	L,S,S	228	South	7
Nov. 16	NFLA	0832	1332	S,L,S	91	South	6
Nov. 17	NFLA	0852	1406	S,S,L	91	South	9
Nov. 19	STEX	0838	1355	S,S,L	91	North	10
Nov. 23	STEX	0921	Survey not completed due to inclement weather				
Nov. 24	STEX	0735	Survey not completed due to inclement weather				
Nov. 25	STEX	0848	1350	S,L,S	228	North	8
Nov. 26	STEX	0855	1338	L,S,S	91	North	2
Nov. 27	NTEX	0830	Survey not completed due to inclement weather				
Nov. 30	NTEX	0826	1315	L,S,S	91	North	3
Dec. 1	NTEX	0801	1243	S,L,S	228	North	3
Dec. 2	NTEX	0754	Survey not completed due to inclement weather				
Dec. 4	NTEX	0812	1251	S,S,L	228	North	1

Oil and Oil Response Activities

The oil spill in the Gulf of Mexico resulting from the Ixtoc well, and the subsequent activities of both U.S. and Mexican agencies, must be considered when evaluating the results of the aerial surveys conducted as a part of the Pilot Study. Significant quantities of oil began entering waters of the Gulf of Mexico in June 1979 and continued flowing at variable rates until 1 March 1980. Oil and petroleum components were conspicuous in both STEX and NTEX survey subunits during August 1979 surveys. At that time oil containment devices were being utilized and tested for some of the coastal lagoons of Texas. Corpus Christi, Texas, was the oil spill response center for U.S. personnel, and as a result air and ship traffic was possibly above normal levels preceding and during some surveys.

The actual effects of oil and oil spill activities on the results of the aerial surveys are unknown because pre-spill baseline data are unavailable. The preliminary data gathered during the Pilot Study potentially establish such a baseline for evaluating oil effects in an indirect manner. All flights were conducted according to the previously developed study plan. Oiled and non-oiled areas were studied with identical intensities and techniques. When possible the location and appearance of presumed oil concentrations were recorded for possible analysis with animal sightings and other environmental data.

Evidence of oil contamination of ocean waters was also noted in Florida survey subunits. In one case, the source of the oil was traced to a Liberian tanker flushing tanks in open water. A group of dolphins were seen swimming through the slick. Such observations were recorded whenever possible.

RESULTS

IDENTIFICATION AND DETECTION

The ability to identify the animal species sighted during aerial surveys was important to the results and quality of the Pilot Study. On occasion conditions were encountered which prevented positive identification of the species or exact composition of mixed groups. In such cases the most detailed identifications available were recorded and analyzed. In some cases identifications were possible at a later time due to increased sightings and incorporation of other data not available at the time of the sighting. On the basis of all data available, probabilistic identifications can be made and the sum of all observations considered in evaluating occurrence, abundance, and movements. For example, tentative groupings such as unidentified dark tern were not necessarily a single species but instead were those animals for which more specific data were unavailable. Dark terns were likely to be black terns, sooty terns, or bridled terns and the availability of tentative data allowed consideration of the total number of possible black, sooty, or bridled tern records.

Mammals

The identification of mammals from an airplane depended upon a number of factors. The behavior, size, and coloration of individual species were critical in making precise identifications. Most species can be readily identified if viewed from the proper angle or vantage point. Most of the animals popularly termed dolphins are similar in body shape and size but differ in head shape, behavior, and subtle aspects of coloration. Bottlenose dolphins were distinctive but not all dolphins were adequately observed to differentiate the bottlenose from other species. Dolphins of the genus *Stenella* were quite similar and consequently difficult to identify to species in all cases. However, because of the paucity of information on the ecology, movements, and behavior of this genus, all data were considered to be of potential value. Three *Stenella* species were identified: spotted dolphin, striped dolphin, and spinner dolphin; although the last species was identified tentatively and only once.

Dolphin groups containing 20 to 150 animals were often sighted over large distances whereas individuals or small groups were seldom seen except near the transect line or immediately perpendicular to the plane's position. Because large groups presented more visual cues, most could be identified. In contrast, individuals and small groups were less likely to be viewed adequately for identification of species. Thus, the number of sightings of unidentified dolphin groups probably represented a small percentage of the total number of dolphins relative to the number of identified individuals and groups.

Pilot whales were sighted in association with fish schools and feeding flocks of birds. Such association allowed detection from greater distances than other solitary animals of comparable sizes.

Large whales are more easily detected even over long distances. Identification was possible except when a whale was sighted from a distance and sounded prior to the approach of the aircraft.

The effect of altitude on detection and identification of marine mammals was investigated using the data available.

Birds

Marine birds provide problems for aerial censusing which are very different from those of marine mammals and turtles. Birds are much smaller than most marine mammals and turtles. They are also more mobile and may fly to high altitudes above the ocean's surface. In general, conspicuousness is a function of size, color, and behavior. Large birds and white birds are more conspicuous than small and dark birds, and birds that stay near the water surface are less conspicuous than those that fly several meters higher. Identification is affected by these same variables but is mainly a function of taxonomic diversity. The rest of this section is a brief review of the conspicuousness and identification problems of the birds we encountered in the pilot project.

Shearwaters are easily identified as such by their characteristic shape and manner of flight. The two species seen (Cory's and Audubon's) are easily distinguished from one another by their plumage patterns, but Audubon's may be impossible to distinguish from the air from the very rare Manx shearwater. The shearwaters are dark above and usually stay close to the water, so they are more difficult to detect than pale birds such as terns.

Storm-petrels are very small, and most are dark colored. Most storm-petrels are probably missed in censuses conducted from 228-m altitude, and they may be missed at 91 m. The three species (Wilson's, Leach's, and Harcourt's) likely to occur in the Gulf of Mexico are very similar in plumage and we did not identify many individuals to species.

Tropicbirds are fairly large and predominately white. They also typically fly at an altitude of at least several meters and are very conspicous. They can be confused only with the larger pale terns; however, their shape and wingbeat are distinctive.

White and brown pelicans are among the largest and most conspicuous birds in the area and are probably the most easily identified.

The boobies and gannets are also very conspicuous but masked (blue-faced) boobies can be confused with gannets, particularly as subadults.

Cormorants are so distinctively shaped that they are easy to identify when on the water or flying, and tend to be conspicuous despite their dark color. In Texas we did not distinguish between the very similar olivaceous and double-crested cormorants.

Frigatebirds tend to be very conspicuous because of their large size. They also have a unique profile which makes identification very easy. They have a habit of soaring to great heights, and therefore we probably missed some that were above the altitude of the plane.

Phalaropes are very small, but their pale coloration and flocking habits make them more conspicuous than the storm-petrels. From the air the three species in winter plumage are probably not separable.

Laughing gulls are moderately conspicuous when alone, but their numbers are probably underestimated when they occur in flocks with the more conspicuous royal terns.

The terns are the most abundant birds offshore and the group presents some identification problems.

Royal terns are large, pale, and have relatively broad wings set in the middle of the body. They are very conspicuous, and with practice can be distinguished from the rest of the terns even from 228-m altitude.

Sandwich terns are smaller and more slender than royal terns, but larger than common terns. They can occasionally be distinguished from the related species, but only after experience.

We identified as "common tern group" the species Forster's, common, roseate, and Arctic terns. These four species are very similar and we consider them indistinguishable from the air. They are pale and rather conspicuous, and as a group can be separated rather easily from the other terns.

Least terns are very small and normally occur close to shore. They can be confused with the common group, but have shorter tails, relatively broader wings, and "floppier" flight.

"Pale terns" are unidentified royal, Sandwich, common group, or least terns. As our experience increases, this category should become limited to those seen at great distances or under other poor viewing conditions.

"Dark terns" are unidentified sooty, bridled, and black terns. These species are distinguishable in the field, but many are seen too poorly for positive identification. As a group they are much less conspicuous than the pale terns, and the proportion sighted is likely to be lower.

Turtles

Turtles presented distinct identification and detection problems in relation to birds and mammals. They were usually sighted floating at the surface or swimming immediately below the water surface. Consequently, they presented a low or nonexistent profile except when viewed from above. Head width, carapace shape, body proportions, and color were all useful criteria but depended upon adequate light, sufficient observation time, and proper sighting angle. Turtles, like some birds, were rarely seen at a distance.

Leatherback turtles were conspicuously separated from other species on the basis of color, shape, size, and lack of a keratinized carapace. Green turtles, hawksbills, loggerheads, and ridley turtles were more difficult to positively identify. A percentage of the turtles seen was classed as unidentified turtles, the equivalent of a non-leatherback classification. Loggerheads were often identifiable on the basis of head and neck size, and red carapace coloration.

OCCURRENCE

Mammals

The marine mammal faunas of the Texas and Florida survey subunits appeared quite different in our surveys (Table 3). Bottlenose dolphins were the only marine mammals found in all survey subunits. They were found only during November in STEX, but were present during both August and November in the other subunits.

During August dolphins of the genus Stenella were common off Florida and Texas. Three species of Stenella were observed off Texas (spotted, striped, and spinner dolphins). All those identified to species off Florida were striped dolphins (a single Stenella in NFLA was called a possible spotted dolphin). During November striped dolphins and unidentified Stenella dolphins were reported in the Florida survey subunits, but no Stenella were reported off Texas.

Saddleback dolphins were identified during August in NFLA and both Texas survey subunits. They were not seen in SFLA nor in any subunits during November.

In the Texas survey subunits we had several sightings of whales. During August sperm whales were seen in both STEX and NTEX, and a group of beaked whales was seen in STEX. Short-finned pilot whales were observed in STEX during August and November, and an unidentified small whale was seen there in August. In contrast, we had only one whale sighting for Florida: an unidentified large whale in NFLA during August.

Our only manatee sighting was in SFLA during November, where three animals were seen approximately 100 m from shore.

Birds

Table 4 summarizes bird species occurrence by area and season. Table 5 provides scientific names for all sea birds expected to occur in the study area. We identified 21 species of birds and recorded an additional 14 categories of birds not identified to species. Most of the recorded avifauna can be grouped into the following categories: migrating landbirds, summer migrant pelagics, summer residents, wintering marine species, and permanent residents.

We identified four species of migrating landbirds: the great egret (Casmerodius albus), cattle egret (Bubulcus ibis), Cooper's hawk (Accipiter cooperii), and willet (Catoptrophorus semipalmatus). Several smaller landbirds were seen and not identified (these are included in Table 4 in the unidentified bird categories).

Table 3. Summary of all marine mammal species sighted in the four survey subunits during the August (A) and November/December (N) surveys.

Species	Survey subunit STEX	NTEX	NFLA	SFLA
Unidentified beaked whale (*Mesoplodon* sp.)	A			
Sperm whale (*Physeter catodon*)	A	A		
Short-finned pilot whale (*Globicephala macrorhynchus*)	AN			
Unidentified whale	A (Small)	N	A	
Bottlenose dolphin (*Tursiops truncatus*)	N	AN	AN	AN
Spinner dolphin (*Stenella longirostris*)		A		
Spotted dolphin (*S. plagiodon*)	A	A	A	
Striped dolphin (*S. coeruleoalba*)	A	A	A	AN
Stenella sp.	A	A	AN	AN
Saddleback dolphin (*Delphinus delphis*)	A	A	A	
Unidentified dolphin	AN	AN	AN	AN
Caribbean manatee (*Trichechus manatus*)				N

Table 4. Summary of all bird species sighted in the four survey subunits during the August (A) and November/December (N) surveys.

Species	Survey subunit			
	STEX	NTEX	NFLA	SFLA
Common loon				N
Cory's shearwater	A	A		AN
Audubon's shearwater	A			
Unidentified shearwater	A	A		
Storm-petrel	AN	A		A
Tropicbird	A			
Brown pelican	N		AN	AN
Masked booby	A	A		
Brown booby	A			
Unidentified booby		A		
Northern gannet	A		A	
Cormorant	N		AN	
Magnificent frigatebird		A	AN	AN
Unidentified duck		N		N
Phalarope	A	AN	N	
Herring gull	N	N	N	N
Laughing gull	A	AN	AN	AN
Unidentified gull	AN	AN	AN	AN
Common tern group		A		AN
Sooty tern	A	A		A
Bridled tern	A		A	A
Least tern		A		A
Royal tern	AN	AN	AN	AN
Sandwich tern		A	A	AN
Black tern	A	A		AN
Unidentified dark tern	AN	N	A	A
Unidentified pale tern	AN	A	A	AN
Unidentified tern	AN	AN	AN	AN
Great (common) egret		N		
Cattle egret			A	N
Cooper's hawk				N
Willet			A	
Unidentified dark bird	N	AN	N	
Unidentified white bird	AN	AN	A	AN
Unidentified bird	AN	AN	AN	AN

Table 5. A primary list of sea birds occurring in waters of the Atlantic Ocean and Gulf of Mexico off the Southeastern United States.

Common name	Scientific name
Common loon	Gavia immer
Arctic loon	Gavia arctica
Red-throated loon	Gavia stellata
Red-necked grebe	Podiceps grisegena
Horned grebe	Podiceps auritus
Eared grebe	Podiceps nigricollis
Least grebe	Podiceps dominicus
Western grebe	Aechmophorus occidentalis
Pied-billed grebe	Podilymbus podiceps
Yellow-nosed albatross	Diomedea chlororhynchos
Black-browed albatross	Diomedea melanophris
Northern fulmar	Fulmarus glacialis
Cory's shearwater	Calonectris diomedea
Greater shearwater	Puffinus gravis
Sooty shearwater	Puffinus griseus
Manx shearwater	Puffinus puffinus
Audubon's shearwater	Puffinus l'herminieri
Black-capped petrel	Pterodroma hasitata
Leach's storm-petrel	Oceanodroma leucorhoa
Harcourt's storm-petrel	Oceanodroma castro
Wilson's storm-petrel	Oceanites oceanicus
White-tailed tropicbird	Phaethon lepturus
American white pelican	Pelecanus erythrorhynchos
Brown pelican	Pelecanus occidentalis
Masked booby (= blue-faced booby)	Sula dactylatra
Brown booby	Sula leucogaster

Table 5. Continued.

Common name	Scientific name
Northern gannet	Morus bassanus
Great cormorant	Phalacrocorax carbo
Double-crested cormorant	Phalacrocorax auritus
Olivaceous cormorant	Phalacrocorax olivaceus
Magnificent frigatebird	Fregata magnificens
Northern phalarope	Lobipes lobatus
Red phalarope	Phalaropus fulicarius
Pomarine jaeger	Stercorarius pomarinus
Parasitic jaeger	Stercorarius parasiticus
Long-tailed jaeger	Stercorarius longicaudus
Great skua	Catharacta skua
South Polar skua	Catharacta maccormicki
Glaucous gull	Larus hyperboreus
Iceland gull	Larus glaucoides
Great black-backed gull	Larus marinus
Lesser black-backed gull	Larus fuscus
Herring gull	Larus argentatus
California gull	Larus californicus
Ring-billed gull	Larus delawarensis
Black-headed gull	Larus ridibundus
Laughing gull	Larus atricilla
Franklin's gull	Larus pipixcan
Bonaparte's gull	Larus philadelphia
Black-legged kittiwake	Rissa tridactyla
Sabine's gull	Xema sabini
Gull-billed tern	Gelochelidon nilotica

Table 5. Concluded.

Common name	Scientific name
Forster's tern	Sterna forsteri
Common tern	Sterna hirundo
Arctic tern	Sterna paradisaea
Roseate tern	Sterna dougallii
Sooty tern	Sterna fuscata
Bridled tern	Sterna anaethetus
Least tern	Sterna albifrons
Royal tern	Sterna maxima
Sandwich tern	Sterna sandvicensis
Caspian tern	Sterna caspia
Black tern	Chlidonias niger
Brown noddy	Anous stolidus
Black noddy	Anous minutus
Black skimmer	Rynchops niger
Razorbill	Alca torda
Thick-billed murre	Uria lomvia
Dovekie	Alle alle

The summer migrant pelagic birds are those that breed elsewhere, but are present in the Gulf of Mexico mainly during summer. Shearwaters, storm-petrels, boobies, tropicbirds, phalaropes, bridled terns, and black terns are in this category. Cory's shearwaters are migrants from Mediterranean and eastern subtropical Atlantic breeding colonies and are common off the southern Atlantic coast and uncommon during summer in the Gulf of Mexico. Our August survey data constitute most of the Cory's shearwater sightings for Texas. Aubudon's shearwaters and bridled terns breed in scattered colonies throughout the Bahamas, elsewhere in the Caribbean, and widely elsewhere in tropical and subtropical oceans. Both are uncommon or rare visitors to the Gulf of Mexico during August. We sighted several storm-petrels in the Gulf of Mexico during August. These were probably Wilson's storm-petrels, but Wilson's, Leach's, and Harcourt's storm-petrels are all found in the Gulf of Mexico. There was one tropicbird sighting in STEX. Tropicbirds are rare warm weather visitors from the Caribbean. Black terns breed on inland lakes and marshes and migrate through the Gulf of Mexico during August and the following months. There were large numbers of black terns sighted during August (especially in Texas) and a few in SFLA during November. Phalaropes breed in marsh and tundra habitats and winter at sea. We recorded a few phalaropes in NTEX during August and November.

The summer residents are sooty terns and least terns. Sooty terns breed in a huge colony on Bush Key, the Dry Tortugas, and in very small colonies in Louisiana and Texas. A few were seen in STEX and SFLA during August. Least terns breed in scattered colonies along the coast of the Gulf of Mexico and winter south of the United States. We saw a few nearshore in the NTEX and SFLA subunits.

The wintering marine species include common loons, northern gannets, various ducks, and herring gulls. Loons winter nearshore along the coast of the Gulf of Mexico, while gannets winter farther offshore. Some subadult gannets may remain in the Gulf of Mexico through the summer. Herring gulls and several species of ducks migrate from their northern breeding grounds to winter in the coastal waters of the Gulf of Mexico; some ducks continue to South America.

The resident species include brown pelicans, cormorants, laughing gulls, and royal terns. These all breed along the coast of the Gulf of Mexico and remain in the area throughout the year. We commonly recorded brown pelicans in both Florida survey subunits, but in Texas where they are now very rare, we recorded them only in STEX and only during November. The laughing gulls and royal terns breed at various localities around the Gulf of Mexico and also to the north. They were present in all survey subunits during both seasons. There was a major influx of royal terns into the Florida survey subunits during November.

Magnificent frigatebirds, Sandwich terns, and members of the common tern group do not fit well into the aforementioned categories.

Frigatebirds breed in one small colony in the Florida Keys, but most of the frigatebirds in the Gulf of Mexico are non-breeders from farther south in the Caribbean. This non-breeding population is much larger in summer than winter, but some remain, at least in South Florida, through the winter. During August we found them to be common in Florida and rare in NTEX. During November they were uncommon in Florida.

Sandwich terns breed in large colonies in the northern Gulf of Mexico and sparingly farther north. They winter in much smaller numbers on the Florida coast of the Gulf of Mexico: most of the population migrates south into the Caribbean.

The common tern group does not fit a pattern, as it is composed of one species that is a rare summer resident, another that is an uncommon breeder and common wintering bird in the Gulf of Mexico, another that is an uncommon migrant and wintering bird, and a fourth that is an accidental migrant. Roseate terns breed in small numbers in the Florida Keys, while Forster's terns breed uncommonly in the northern Gulf of Mexico and winter commonly on the coast of the Gulf of Mexico. Common terns are uncommon migrants and wintering birds, and arctic terns are accidental in the Florida Keys and very rare as migrants off the east coast of Florida.

Turtles

Four taxa of turtles were encountered in aerial surveys (Table 6). Loggerheads were conspicuous in Florida survey subunits but were infrequently sighted in Texas. The endangered Kemp's ridley was sighted only in Texas, and there in low numbers. Leatherbacks were evident but in low numbers in Florida. Green turtles of various size classes can resemble members of all other sea turtle taxa except the leatherback, so many turtles could not be identified to species.

The preponderance of turtles in Florida in relation to Texas possibly reflects two facts. First, Florida includes nesting beaches for three marine turtle species (loggerhead, green, and leatherback turtles). Second, the species of primary importance in the western Gulf of Mexico, Kemp's ridley, has been severely reduced over the last four decades. Although all species present in the Gulf of Mexico are historically known from the Texas coast, surveys over an annual cycle may be necessary to elucidate the degree of utilization of the area by marine turtles.

SEASONAL VARIATION

Mammals in STEX

The frequency of sightings of mammals in the South Texas survey subunit declined by 33.3% from August to November (Table 7). Of the nine taxa seen in August, only three were noted in November. Bottlenose dolphins, which were not observed in August, accounted for 71.4% of the sightings in November. Short-finned pilot whales were noted during both STEX surveys. Dolphins of the genus *Stenella* were conspicuously absent from observations in November.

The absence of records for bottlenose dolphins in STEX during August is paralleled by observations made in transit along the coast between Corpus Christi and Brownsville. Bottlenose dolphins were not observed during flights paralleling the Laguna Madre and adjacent onshore waters of the Gulf of Mexico even though these included the shallow depths near the coast that are frequented by bottlenose dolphins throughout the range of the species.

Table 6. Summary of turtles observed during August and November/December 1979 surveys. LHTU = Loggerhead (Caretta caretta); GRTU = Green (Chelonia mydas); LBTU = Leatherback (Dermochelys coriacea); KRTU = Kemp's Ridley (Lepidochelys kempi); and UNTU = Unidentified species.

Date	Survey subunit	LHTU	GRTU	LBTU	KRTU	UNTU	Total
Aug. 5	SFLA	17	4	0	0	12	33
Aug. 6	SFLA	23	0	2	0	15	40
Aug. 7	SFLA	12	0	0	0	7	19
Aug. 8	NFLA	13	0	0	0	3	16
Aug. 9	NFLA	23	0	1	0	1	25
Aug. 10	NFLA	31	0	0	0	13	44
Aug. 20	STEX	0	0	0	0	1	1
Aug. 21	STEX	0	0	0	0	0	0
Aug. 22	STEX	0	0	0	2	0	2
Aug. 23	NTEX	0	0	0	0	0	0
Aug. 24	NTEX	1	0	0	0	0	1
Aug. 25	NTEX	0	0	0	0	1	1
Nov. 8	SFLA	13	0	0	0	4	17
Nov. 9	SFLA	11	0	0	0	0	11
Nov. 10	SFLA	12	0	0	0	2	14
Nov. 15	NFLA	12	0	0	0	1	13
Nov. 16	NFLA	10	0	0	0	1	11
Nov. 18	NFLA	10	0	1	0	1	12
Nov. 19	STEX	0	0	0	1	0	1
Nov. 25	STEX	0	0	0	0	0	0
Nov. 26	STEX	0	0	0	0	0	0
Nov. 30	NTEX	0	0	0	0	1	1
Dec. 1	NTEX	0	0	0	0	0	0
Dec. 4	NTEX	0	0	0	0	0	0

Table 7. Seasonal variation in relative abundance of marine mammal sightings in the STEX survey subunit.

Species	August		November	
	No.	%	No.	%
Sperm whale	1	4.8	0	0.0
Unidentified whale	1	4.8	0	0.0
Bottlenose dolphin	0	0.0	10	71.4
Beaked whale	1	4.8	0	0.0
Short-finned pilot whale	1	4.8	1	7.1
Striped dolphin	1	4.8	0	0.0
Spotted dolphin	2	9.5	0	0.0
Stenella sp.	5	23.8	0	0.0
Saddleback dolphin	1	4.8	0	0.0
Unidentified dolphin	8	38.1	3	21.4
Totals	21	100.0	14	100.0

Table 8. Seasonal variation in relative abundance of marine mammal sightings in the NTEX survey subunit.

Species	August		November	
	No.	%	No.	%
Sperm whale	1	3.5	0	0.0
Unidentified whale	0	0.0	1	11.1
Bottlenose dolphin	10	35.7	7	77.8
Striped dolphin	1	3.5	0	0.0
Spinner dolphin	1	3.5	0	0.0
Spotted dolphin	2	7.0	0	0.0
Stenella sp.	2	7.0	0	0.0
Saddleback dolphin	1	3.5	0	0.0
Unidentified dolphin	10	35.7	1	11.1
Totals	28	100.0	9	100.0

Mammals in NTEX

In NTEX eight taxa were sighted a total of 28 times during August (Table 8). In the same subunit during November surveys, only three taxa were encountered for a total of nine sightings. Sperm whales, striped dolphins, spinner dolphins, spotted dolphins, unidentified Stenella, and saddleback dolphins were sighted during August but not November. The only taxon sighted during November surveys of NTEX and not encountered during August was an unidentified whale sighted with a group of bottlenose dolphins. This individual was medium in size, but could not be identified more precisely. Dolphins composed 95.9% of the mammal fauna during August and 88.9% during November. Bottlenose dolphin groups composed 37.0% of the dolphin sightings in August and 87.5% of such sightings in November. Although the number of groups of bottlenose dolphins sighted declined from 10 to 7 from August to November, other dolphin species present in August were not encountered at all in November surveys.

Mammals in NFLA

The number of mammal groups sighted in NFLA was reduced by nearly 50% (45.2%) during November in relation to August (Table 9). Three taxa were recorded during November whereas seven were observed during August. Bottlenose dolphins composed 45.1% and 58.8% of the August and November group sightings, respectively. Although three groups of unidentified Stenella, (17.7%) were present in November, the congeneric species (spotted dolphin and striped dolphin) were not identified. Considering all species of the genus Stenella, November sightings were only 37.5% of those in August. Saddleback dolphins, which represented 9.7% of the sightings in August were not observed in November.

Mammals in SFLA

The number of sightings in SFLA (Table 10) was only slightly reduced, 14.7%, during November in relation to August. This change was primarily the result of differences in the number of sightings of pelagic dolphins of the genus Stenella: 11 (32.4% of the mammal fauna) during August and 5 (17.3%) during November. In contrast to dolphin populations in both northern subunits, bottlenose dolphins in SFLA were sighted more frequently in November than in August. The appearance of a single manatee in the coastal margin of SFLA in November may be related to the season or to local movements in response to other factors. Manatees were present during both months but were not commonly seen due to the inshore habits of this species (Irvine et al. In press).

Of the four survey subunits, only in SFLA were all taxa that were encountered in August, also recorded in November. Other subunits showed more conspicuous reductions in the frequency and diversity of sightings. Both STEX and SFLA surveys during November resulted in increased sightings of bottlenose dolphins. The absence of records for sperm whales, saddleback dolphins, and Stenella species in Texas survey subunits during November is noteworthy. Less conspicuous but parallel reductions occurred in Florida.

Birds in STEX

Table 11 presents relative frequencies of birds in the STEX survey subunit. Bird sightings were more frequent during November than August (190 vs. 122 records). Terns

Table 9. Seasonal variation in relative abundance of marine mammal sightings in the NFLA survey subunit.

Species	August		November	
	No.	%	No.	%
Unidentified whale	1	3.2	0	0.0
Bottlenose dolphin	14	45.2	10	58.8
Striped dolphin	5	16.1	0	0.0
Spotted dolphin	1	3.2	0	0.0
Stenella sp.	2	6.5	3	17.7
Saddleback dolphin	3	9.7	0	0.0
Unidentified dolphin	5	16.1	4	23.5
Totals	31	100.0	17	100.0

Table 10. Seasonal variation in relative abundance of marine mammal sightings in the SFLA survey subunit.

Species	August		November	
	No.	%	No.	%
Bottlenose dolphin	5	14.7	10	34.5
Striped dolphin	9	26.5	2	6.9
Stenella sp.	2	5.9	3	10.4
Caribbean manatee	0	0.0	1	3.4
Unidentified dolphin	18	52.9	13	44.8
Totals	34	100.0	29	100.0

Table 11. Seasonal variation in relative abundance of bird sightings in the STEX survey subunit. Asterisk (*) indicates groupings of similar birds and those not identified to species. Percentages are computed on the total number of sightings. Species listed separately and in general groups are only counted once in the total number of sightings.

Species	August		November	
	No.	%	No.	%
Cory's shearwater	9	7.4	0	0.0
Audubon's shearwater	2	1.6	0	0.0
All shearwaters*	17	13.9	0	0.0
Storm-petrel	1	0.8	1	0.5
Tropicbird	1	0.8	0	0.0
Brown pelican	0	0.0	1	0.5
Masked booby	2	1.6	0	0.0
All boobies*	6	4.9	0	0.0
Cormorant	0	0.0	1	0.5
Phalarope	2	1.6	0	0.0
Herring gull	0	0.0	26	13.6
Laughing gull	5	4.1	0	0.0
All gulls*	7	5.7	45	23.6
Royal tern	14	11.5	66	34.6
All pale terns*	52	42.6	122	63.9
Sooty tern	3	2.5	0	0.0
Bridled tern	1	0.8	0	0.0
Black tern	12	9.8	0	0.0
All dark terns*	29	23.8	2	1.0
All terns*	81	66.4	124	64.9
Other unidentified birds	7	5.7	19	9.9
Total sightings	122		191	

accounted for two-thirds of all bird sightings in the survey (66.4% in August and 64.9% in November), but the composition of tern species was markedly different. During August pale terns (all that were identified to species were royal terns) accounted for 42.6% of all bird sightings, while dark terns (mostly black terns but a few sooty and bridled tern sightings) accounted for 23.8%. In contrast, dark terns accounted for only 1.0% of November sightings and pale terns accounted for 63.9%. Gulls accounted for 23.6% of the November sightings and only 5.7% in August, reflecting the influx of herring gulls from the northern United States and Canada. The August survey found a variety of non-breeding summer visitors, including shearwaters, boobies, storm-petrels, and a tropicbird, which were not present in November.

Birds in NTEX

The frequencies of bird sightings in NTEX are presented in Table 12. Terns accounted for 75.8% of all sightings in August but for only 34.5% of the November sightings. Dark terns were rare in both surveys (3.4% in August, 1.1% in November); therefore, the decrease was primarily in the frequency of sightings of royal and unidentified pale terns. Herring gulls were absent in August but accounted for 43.7% of the November bird sightings. Shearwaters, storm-petrels, boobies, and magnificent frigatebirds were sighted during August but not November. One group of ducks was observed during November.

Birds in NFLA

The frequencies of bird sightings in NFLA are presented in Table 13. There was a conspicuous increase in the number of royal terns sighted during November (64.4% of the bird fauna) in relation to August (30.2%). The number of brown pelicans seen was stable between the two surveys, but in November brown pelicans composed 9.2% of the bird fauna as compared to 17.9% in August. Frigatebirds were seldom seen in November in relation to the August survey. Laughing gulls were more frequently sighted in November with all gull species accounting for 12.1% of the November sightings. Dark terns were not sighted in November whereas nine groups were recorded in August.

Birds in SFLA

Table 14 presents relative frequencies of birds in the SFLA survey subunit. Royal terns were more commonly sighted in November than in August: they accounted for 17.8% and 69.5% of the bird sightings in August and November, respectively. Brown pelicans and laughing gulls showed a similar but less pronounced increase in November. Common group, least, sooty, and bridled terns were present in August but were not sighted in November. Cory's shearwaters and Sandwich terns were seen in low numbers during both months.

Turtles in Texas and Florida

The frequency of sightings of marine turtles in Florida greatly exceeded that in Texas (Table 15). Of all turtle sightings 97.3% were in Florida survey subunits and 2.7% were in Texas. The total number of turtles seen in August (182) exceeds the total for November (80). Turtles were approximately equal in abundance in NFLA and SFLA, with reductions during November surveys of slightly under 50% in relation to August surveys (Table 16). Leatherback turtles were sighted in Florida during both August and

Table 12. Seasonal variation in relative abundance of bird sightings in the NTEX survey subunit. Asterisk (*) indicates groupings of similar birds and those not identified to species. Percentages are computed on the total number of sightings. Species listed separately and in general groups are only counted once in the total number of sightings.

Species	August		November	
	No.	%	No.	%
Cory's shearwater	4	2.2	0	0.0
All shearwaters*	5	2.8	0	0.0
Storm-petrel	1	0.6	0	0.0
Masked booby	4	2.2	0	0.0
All boobies*	4	2.2	0	0.0
Magnificent frigatebird	3	1.7	0	0.0
Ducks	0	0.0	1	1.1
Phalarope	3	1.7	1	1.1
Herring gull	0	0.0	38	43.7
Laughing gull	21	11.8	2	2.3
All gulls*	27	15.2	50	57.5
Common tern group	2	1.1	0	0.0
Least tern	1	0.6	0	0.0
Royal tern	75	42.1	26	29.9
Sandwich tern	1	0.6	0	0.0
All pale terns*	129	72.5	29	33.3
Sooty tern	1	0.6	0	0.0
Black tern	5	2.8	0	0.0
All dark terns*	6	3.4	1	1.1
All terns*	135	75.8	30	34.5
Other birds	0	0.0	5	5.7
Total sightings	178		87	

Table 13. Seasonal variation in relative abundance of bird sightings in the NFLA survey subunit. Asterisk (*) indicates groupings of similar birds and those not identified to species. Percentages are computed on the total number of sightings. Species listed separately and in general groups are only counted once in the total number of sightings.

Species	August		November	
	No.	%	No.	%
Brown pelican	38	17.9	41	9.2
Northern gannet	1	0.5	0	0.0
Cormorant	1	0.5	2	0.4
Magnificent frigatebird	21	9.9	2	0.4
Herring gull	0	0.0	4	0.9
Laughing gull	1	0.5	34	7.6
All gulls*	2	0.9	54	12.1
Royal tern	64	30.2	288	64.4
Sandwich tern	2	0.9	0	0.0
All pale terns*	136	64.2	334	74.7
Bridled tern	5	2.4	0	0.0
All dark terns*	9	4.2	0	0.0
All terns*	145	68.4	334	74.7
Cattle egret	1	0.5	0	0.0
Willet	1	0.5	0	0.0
Other unidentified birds	2	0.9	14	3.1
Total sightings	212		447	

Table 14. Seasonal variation in relative abundance of bird sightings in the SFLA survey subunit. Asterisk (*) indicates groupings of similar birds and those not identified to species. Percentages are computed on the total number of sightings. Species listed separately and in general groups are only counted once in the total number of sightings.

Species	August		November	
	No.	%	No.	%
Cory's shearwater	1	1.4	1	0.2
Storm-petrel	1	1.4	0	0.0
Brown pelican	4	5.5	11	1.7
Magnificent frigatebird	19	26.0	11	1.7
Double-crested cormorant	0	0.0	1	0.2
Herring gull	0	0.0	1	0.2
Laughing gull	1	1.4	20	3.1
All gulls*	1	1.4	22	3.5
Common tern group	3	4.1	0	0.0
Least tern	1	1.4	0	0.0
Royal tern	13	17.8	443	69.5
Sandwich tern	1	1.4	1	0.2
All pale terns*	33	45.2	566	88.9
Sooty tern	2	2.7	0	0.0
Bridled tern	7	9.6	0	0.0
Black tern	1	1.4	3	0.5
All dark terns*	14	19.2	3	0.5
All terns*	47	64.4	569	89.3
Other birds	0	0.0	22	3.5
Total sightings	73		637	

Table 15. Sighting frequency of marine turtles in Texas and Florida.

Species	Texas		Florida	
	No.	%	No.	%
Loggerhead turtle	1	14.2	187	73.3
Green turtle	0	0.0	4	1.6
Leatherback turtle	0	0.0	4	1.6
Kemp's ridley turtle	3	42.9	0	0.0
Unidentified turtle	3	42.9	60	23.5
Totals	7	100.0	255	100.0

Table 16. Seasonal occurrence of sightings for turtles in Florida.

Species	August		November	
	No.	%	No.	%
NFLA				
Loggerhead turtle	67	78.8	32	88.9
Leatherback turtle	1	1.2	1	2.8
Unidentified turtle	17	20.0	3	8.3
Totals	85	100.0	36	100.0
SFLA				
Loggerhead turtle	52	56.5	36	85.7
Green turtle	4	4.4	0	0.0
Leatherback turtle	2	2.2	0	0.0
Unidentified turtle	34	36.9	6	14.3
Totals	92	100.0	42	100.0

November surveys. Green turtles were only noted during August surveys of SFLA but were possibly included in the unidentified turtle category during other surveys.

Turtles were rarely sighted in Texas surveys. Of those recorded, less than half as many were seen in November as in August. Kemp's ridley turtle was identified only in STEX but was present in both seasons sampled. Loggerhead turtles were sighted in Texas, but with much lower frequencies than in Florida.

The total number of turtle sightings and the relative frequency of the component species varied within predictable limits. As an example, daily counts of loggerhead turtles, unidentified turtles and all turtles in NFLA during August had ranges of 13 to 31, 1 to 13, and 16 to 44 respectively (Table 6). August surveys in SFLA resulted in ranges for the same groupings as follows: 12 to 23, 7 to 15, and 19 to 40.

DAILY VARIATION

The daily variation in sightings of individual species within a single season and geographic area can significantly effect estimates of faunal composition and abundance. The magnitude of variation observed was in part dependent upon factors such as abundance, observability, group size, and mobility. Empirically, taxa that were relatively common on any one day were observed on subsequent days. The number of groups on subsequent days was usually less than 50% above or below the initial frequency. Taxa that were observed one to four times in a single day's flight were less likely to be detected during every day of subsequent flights. Examples of both commonly and sparsely sighted taxa are detailed in Tables 17 and 18. In the case of the unidentified groups such as dark terns, daily variation may have been the result of being able to identify them in certain lighting conditions or group sizes but not in others. The daily totals of all tern groups sighted in August-SFLA surveys are 12, 15, and 20. This pattern shows a greater predictability than the individual taxa in part because of increased sample size and in part because when more groups are specifically identified, a decrease in unidentified taxa is expected. Such variation would be reduced even more when group sizes are considered. Five groups on one day averaging five birds/group may exactly correspond to one group of 25 birds seen on a subsequent day during a different feeding situation, etc. Both group size and group abundance have been analyzed for estimations of relative abundance.

On the basis of the example data in Tables 17 and 18 it is apparent that daily replicates add to the understanding of faunal composition. In SFLA during August (Table 18), the first day's flight resulted in the observation of three mammal taxa and nine bird taxa. On the subsequent day, three mammal taxa and eight bird taxa were noted. However, of the three mammals observed on day 2, one was new to the data set, raising the known number of mammal fauna to four. Of the eight birds seen on day 2, two were new on the data set, resulting in a known bird fauna of 11. On day 3, 1 mammal and 11 bird taxa were observed. Although no new mammal taxa were added, two additional bird taxa were added to the data set even though two other taxa known to occur in the area were not seen. Comparing the actual number of taxa observed with those known on the basis of previous observations, a similar pattern can be seen in August data from NFLA (Table 17). For mammals on days 1, 2, and 3, respectively, the ratios of observed/known taxa are 2/2, 5/6, and 5/7. For birds the ratios are 7/7, 6/7, and 8/9. As of day 3, it was

Table 17. Daily variation in the number of sightings of groups of selected bird and mammal species in the NFLA survey subunit.

Species	Number of Sightings		
	Aug. 8	Aug. 9	Aug. 10
Birds			
Magnificent frigatebird	7	5	9
Brown pelican	9	17	12
Royal tern	11	19	34
Bridled tern	0	0	5
Sandwich tern	2	0	0
Unidentified pale tern	2	2	1
Unidentified dark tern	0	0	4
Unidentified tern	17	19	29
Total unidentified terns	19	21	34
Mammals			
Bottlenose dolphin	5	4	5
Saddleback dolphin	0	3	0
Striped dolphin	0	1	4
Stenella sp.	0	1	1
Spotted dolphin	0	0	1
Unidentified dolphin	0	2	3
Unidentified whale	1	0	0

Table 18. Daily variation in the number of sightings of groups of selected bird and mammal species in the SFLA survey subunit.

Species	Number of Sightings		
	Aug. 5	Aug. 6	Aug. 7
Birds			
Magnificent frigatebird	10	5	4
Brown pelican	3	0	1
Royal tern	4	3	6
Bridled tern	1	5	1
Sandwich tern	0	0	1
Sooty tern	0	2	0
Common tern group	2	0	1
Least tern	1	0	0
Black tern	0	0	1
Unidentified pale tern	1	1	1
Unidentified dark tern	0	1	3
Unidentified tern	3	3	6
Total unidentified terns	4	5	10
Mammals			
Bottlenose dolphin	5	0	0
Striped dolphin	5	4	0
Stenella sp.	0	2	0
Unidentified dolphin	8	8	2

known that seven taxa of mammals and nine taxa of birds occurred in the subunit. For some species the seasonal data set includes three daily estimates of abundance; for others only one or two daily estimates exist.

Clearly, replicates add information and robustness to the sampling strategy. The number of replicates necessary to monitor the entire fauna is unknown. However, the need for replicates and information over a broad geographic area must be balanced with cost, time, and logistical considerations. As seasonal and annual replicates are compared with daily replicates in future studies, an approximation of the relative effectiveness of the sampling strategy will be able to be evaluated.

The seasonal variation seen during the Pilot Study appears to be largely a result of seasonality and not a product of increased sampling as might be expected if three replicates were inadequate to approximate occurrence and frequency.

BATHYMETRY AND DISTANCE FROM SHORE

Marine animals vary in their distribution offshore and in the depths of the waters in which or over which they occur. Both of these variables were analyzed quantitatively as well as graphically. In general, maps were used to illustrate the distribution of animal groups in relation to bathymetric contours and the shoreline, and within the individual survey subunit. These maps also show the position of a species in relation to other species.

In most areas the depth of the ocean increases with the distance offshore. However, the width of the continental shelf affects the relationship of these environmental factors. In the STEX survey subunit the continental shelf is narrow and the 200-m contour is approximately 90 km from the coastline (Map 2). Maximal depths in STEX approach 2,400 m. The bathymetric contours of the NTEX subunit are more complex (Map 3). In the northeastern extreme of this survey subunit, maximal depths are 409 m at a distance approximately 170 m from the nearest point on the Texas coast and over 200 km from the landward extreme of the actual survey subunit. The 200-m contour is within 90 km of shore. The southeastern extreme of the NTEX subunit is near the 1,500-m contour at a distance of 222 km from the shoreline of Texas. The NFLA subunit has a more regular and gradual bathymetric profile with depths of approximately 200 and 280 m, 222 km offshore at the southwestern and southeastern extremes respectively (Map 4). In SFLA the shelf is wider and the 200-m contour is approximately 260 km from the west coast of Florida (Map 5).

The diversity in bathymetric profiles in relation to offshore distance potentially offers an opportunity to separate the relative effects of distance and depth on the distribution of animals in the Gulf of Mexico. If a species was consistently further offshore in areas of greater continental shelf width, depth was considered to be potentially more important than distance in delimiting the movements and occurrence of that species. Identification of such relationships is important for predicting distributions in areas studied less intensively, and for estimating abundance in a variety of geographic and environmental situations.

Waters of moderate to shallow depths are known to support a greater species diversity and abundance than waters further offshore. This relationship between animal distribution and the geographic features of an area is reflected in Maps 6 and 7. The abundance of sightings in nearshore waters during this survey was further accentuated by the study design. The daily flight pattern included six flight segments (75%) within 111 km of the coast and two flight segments (25%) 112 to 222 km from the landward margin of the survey subunit. Since each survey segment was of equal length, inshore areas (i.e., 0 to 111 km offshore) were surveyed with three times the intensity of those offshore (112 to 222 km offshore). Such a hierarchical sampling regime will potentially allow determination of sampling efficiency in the two levels of effort. The relative sampling effort has been considered in formulating conclusions from the data set.

Mammals in STEX

No bottlenose dolphins were sighted in STEX subunits during August, but 10 groups were observed in inshore waters of less than 60 m depth ($\bar{x}$ = 45 m) during November (Map 8). Of the unidentified dolphins seen during August, only one of eight (12.5%) was in water less than 50 m in depth (Map 9). The remainder, 87.5%, were beyond the 100-m contour and over 100 km from shore. All of the unidentified *Stenella* observed were at or beyond the 100-m contour and up to 200 km offshore (Map 9). Of the three groups of unidentified dolphins seen in November, all were confined to the southern margin of the survey subunit near the U.S./Mexican territorial limit. They were equally distributed in shallow, moderate, and deep water areas (Map 10).

Short-finned pilot whales were seen in waters approximately 700 m deep during August and November (Map 11). They apparently occurred further inshore than sperm whales, unidentified beaked whales, and other unidentified whales seen during August (Map 12).

Mammals in NTEX

Bottlenose dolphins were distributed in nearshore waters of less than 60 m during August (Map 13). Unidentified dolphin groups extended further offshore during the same period (Map 14). The mean depth for bottlenose dolphins was 39 m, whereas 30% of the unidentified dolphin groups were beyond the 200-m contour. This suggests that some of the unidentified dolphin groups represented species other than bottlenose dolphins. Two groups of unidentified *Stenella* were between the 50- and 100-m contours (Map 14), a striped dolphin group was sighted inside the 50-m depth contour (Map 15), and spotted dolphins, spinner dolphins, and saddleback dolphins were in waters from 100 to 1,000 m in depth (Map 15).

A single group of sperm whales (three females and one calf) was sighted during August. The sperm whales were approximately 222 km offshore, close to the 1,000-m contour (Map 13).

During November one group of bottlenose dolphins, located in proximity to an unidentified small whale, was encountered beyond the 200-m contour (Map 16). However, 71% of all bottlenose dolphin sightings in November were within the 50-m contour. The only sighting of unidentified dolphins during November was in water beyond the 200-m contour (Map 16).

Mammals in NFLA

The marine mammals sighted within the NFLA subunit during August were distributed into three assemblages on the basis of water depth. Bottlenose dolphins were conspicuously concentrated inshore in relatively shallow waters (Map 17). Of 14 groups recorded, 9 (64%) were in waters less than 10 m deep, and all were in depths less than 80 m. All Stenella species (including the spotted dolphin, striped dolphin, and unidentified Stenella) were in waters deeper than 25 m (Map 18). Two groups of striped dolphins (25% of all Stenella) were near the 200-m contour and nearly 200 km offshore. Three groups of saddleback dolphins were near the 100-m contour. A single unidentified whale can be considered a deepwater constituent. It was sighted over 200 km from shore and beyond the 200-m contour (Map 17).

During November bottlenose dolphins were in waters with a mean depth of 17.7 m (the August mean was 35.9 m). Unidentified Stenella also appeared in shallower water during November (August $\bar{x}$ = 78.7 m; November $\bar{x}$ = 58.8 m).

Mammals in SFLA

The mammals observed in SFLA during August consisted of a shallow water form, bottlenose dolphins, and several mid to deep water species, including Stenella species and unidentified dolphins. The five bottlenose dolphin groups identified were within the 30-m depth contour (Map 19). Of the unidentified dolphin groups, seven (38.9%) were within the 30-m contour and were suspected to represent bottlenose dolphin groups (Map 19). The remaining unidentified dolphins (ca. 60%) were in waters 30 to 70 m deep. Two groups of unidentified Stenella (Map 20) were sighted at similar depths (i.e., between the 35- and 45-m contours). Striped dolphins (Map 20) occurred in waters 20 to 80 m in depth ($\bar{x}$ = 43.3 m); 56% of these were outside the 30-m depth contour. Only a small percentage of the striped dolphins and the unidentified dolphin groups were seen in the extreme seaward sections of the SFLA survey subunit.

During November surveys of SFLA, 10 groups of bottlenose dolphins were sighted in waters less than 50 m deep; 80% were in waters within the 30-m contour. A single striped dolphin group was sighted in 18-m water, the shallow extreme of all August sightings for this species. Unidentified Stenella were in waters with a mean depth of 28.9 m.

Birds in STEX

STEX has the narrowest continental shelf of any of the survey subunits, so a higher proportion of the survey time was spent flying over deep water in this subunit than in the others. This was reflected in the bird fauna, for the offshore component was more prominent here than in the other survey subunits.

All of the summer migrant pelagic species seen in the surveys were present in STEX during August; no other survey subunit had even half these species. The only brown booby seen in the surveys was here, in water 650 m deep (ca. 100 km offshore). More Cory's shearwaters than had been recorded previously from Texas were seen in our STEX-August survey. Our nine sightings (Map 21), involving about 200 birds, were clustered in waters 130 to 800 m deep, although one was in water over 1,000 m deep. Audubon's shearwater, storm-petrel, and unidentified shearwater records are displayed on Map 22.

Two Audubon's shearwaters were seen: one was in water 70 m deep and the other was well beyond the 1,000-m contour. The five storm-petrel records all fell between the 100- and 1,000-m contours. Map 23 shows the locations of the only tropicbird seen during all the surveys and the only bridled tern seen in Texas. Both occurred well seaward of the 1,000-m contour. Black terns and unidentified dark terns (Maps 24 and 25) were concentrated beyond the 200-m contour, although both occurred closer to shore in 30-m depths as well.

Royal terns (Map 26) were found out to depths of 50 m, but were concentrated between 20 and 30 m. Unidentified pale terns (we suspect most were royal) were also concentrated inshore of the 30-m contour, but two sightings were made approximately 100 km out from shore over water in excess of 200 m deep (Map 27). Most laughing gull and unidentified gull sightings were made inshore of the 30-m contour (Map 28), but one laughing gull was seen in a flock of shearwaters and dark terns more than 100 km from shore over water 650 m deep.

Northern gannets and masked boobies were seen inshore, at times near oil drilling rigs. However, one masked booby was sighted beyond the 200-m contour.

During November the offshore element of the bird fauna was not present. Royal terns (Map 29) were found concentrated inshore, just as in August. Eighty-eight percent of the groups sighted were inshore of the 40-m contour; only one was seen beyond the 200-m contour. Unidentified terns (Map 30), herring gulls (Map 31), and unidentified gulls (Map 32) all followed the same inshore pattern.

The only brown pelican seen in the Texas surveys was observed during November. It was located in the southwestern corner of the STEX subunit in water approximately 20 m deep.

<u>Birds in NTEX</u>

Most birds were inshore during August, but the offshore element of the bird fauna was represented by at least three species. Of the summer migrant pelagics, four Cory's shearwaters, two storm-petrels, and an unidentified shearwater (probably Cory's) were recorded (Map 33). All were over water more than 50 m deep, and one Cory's shearwater was seaward of the 1,000-m contour. One sooty tern was seen over water 860 m deep (Map 34).

The inshore fauna observed during August was represented by royal terns (Map 34), common group and Sandwich terns (Map 35), unidentified pale terns (Map 36), laughing gulls (Map 37), and magnificent frigatebirds (Map 38). Royal terns occurred out to the 70-m contour, but 81% were inshore of the 40-m contour. Unidentified pale terns (which were suspected to be royal terns) had a similar distribution, with 83% inshore of the 40-m contour. All laughing gulls were inshore of the 20-m contour. The three magnificent frigatebird sightings were at the 10-, 20-, and 60-m contours.

Two species, the masked booby and black tern, had intermediate distributions during August (Map 39). The four masked booby sightings were between the 45- and 60-m contours. Black terns were migrating from the North American continent out into the Gulf of Mexico, and our sightings were distributed from the nearshore shallows out to water over 450 m deep. The only least tern recorded during the Texas surveys was seen in NTEX near the 100-m contour (Map 35). This tern may have been a migrant.

The distribution of birds with respect to bathymetry was simpler in November than in August. The offshore element was gone, and essentially all birds were found over relatively shallow water. Royal terns occurred out to the 100-m contour (Map 40), but 81% were inshore of 40 m, just as in August. The two laughing gull groups identified were in waters 10 and 36 m deep (Map 40). Herring gulls, absent in August, were common in November (Map 41). They occurred out to the 60-m contour and, like royal terns, 81% occurred inside the 40-m contour. We also recorded 10 sightings of unidentified gulls distributed rather evenly between the 10- and 50-m contours (Map 42).

Birds in NFLA

Practically all birds seen in NFLA during August were relatively close to land. The only summer migrant pelagic species identified was the bridled tern; other unidentified dark terns may have also been bridled terns (Map 43). The two Sandwich tern groups seen were both over 160 km from land and over water in excess of 100 m deep (Map 44). This species generally is considered an inshore tern, so perhaps these sightings were of migrants moving southward from the large Louisiana colonies.

The rest of the birds seen during August were restricted to inshore, shallow areas. Eighty-one percent of the royal tern sightings were over water less than 20 m deep, and all were landward of the 30-m contour (Map 44). The brown pelican sightings also were all landward (east) of the 30-m contour, and 66% were over water less than 10 m deep (Map 45). Magnificent frigatebirds (Map 46) ranged farther out to sea than the pelicans and royal terns, but still 81% were landward of the 20-m contour. The westernmost sighting of a magnificent frigatebird group was over water 45 m deep, about 50 km from shore.

The November sightings of birds in NFLA were predominantly in nearshore waters. However, both brown pelicans and royal terns tended to range further offshore than they did during August. Mean depths for brown pelicans and royal terns were 29.9 and 22.4 m, respectively. Magnificent frigatebirds were present in low numbers inside the 10-m contour.

Birds in SFLA

The bird fauna in SFLA during August can be grouped into coastal and offshore elements. The coastal element consisted mostly of permanent and summer residents, while the offshore element was composed of summer migrant pelagics and the summer resident, sooty tern.

The coastal element included brown pelicans, magnificent frigatebirds, and various pale terns. Brown pelicans were recorded only in the northeast corner of the survey subunit within 40 km of land (Map 47). Least, common group, and Sandwich terns were found in the same area, close to land and mostly within the 25-m contour (Map 48). Royal terns were identified only landward of the 25-m contour (Map 47), although four unidentified terns offshore between the 25- and 50-m contours may have been royal terns (Map 49). Magnificent frigatebirds were most common nearshore, but ranged over the eastern two-fifths of the survey subunit (Map 50). They were recorded several times in the southern part of the subunit, suggesting regular movements between the peninsular Florida coast of the Gulf of Mexico and the outer Florida Keys. Several sightings of magnificent frigatebirds were also made over waters between 25 and 50 m deep.

The offshore element included sooty and bridled terns, Cory's shearwaters, and storm-petrels (Map 51). Sightings of these birds were rare and all were far offshore, seaward of the 50-m contour.

The bird fauna of SFLA contained fewer species in November than August. Of the coastal forms, brown pelicans and magnificent frigatebirds occupied the same areas of the survey subunit that they had during August. Least terns were absent in November. Royal terns were more common and more widely distributed throughout the subunit with 0 to 50 m water depths ($\bar{x}$ = 24.3 m). Unidentified terns showed a similar distribution, occurring inside the 50-m contour. Laughing gulls were more restricted to nearshore situations, with 90% of all groups occurring within the 25-m contour. Herring gulls were also in nearshore waters only.

The offshore elements were rare and included Cory's shearwaters and black terns in waters 30 to 60 m deep.

Turtles in Texas

The sparse sightings of turtles in Texas waters prevent conclusive analysis of distributional variation. Table 19 lists these sightings, showing the water depth and distance from shore for each observation. Two of the three Kemp's ridleys seen were less than 30 km offshore in waters approximately 30 m deep (Map 52). The third ridley was in much deeper water (i.e., 409 m) and approximately 100 km offshore. During November one unidentified turtle (not a ridley) occurred 93 km from shore in water with a depth of 127 m (Map 53). Three other turtles (one loggerhead and two unidentified turtles) observed during August were within 100 km of shore in water less than 75 m deep (Maps 52 and 53).

All turtles observed in Texas were in proximity to water containing oil pancakes or sheen. The ridley recorded in Texas was also in proximity to oiled water. Sargassum was common in Texas waters, and four of five turtles seen during August were near large large clumps or windrows of sargassum.

Turtles in NFLA

Loggerhead turtles occurred in waters with depths of less than 200 m ($\bar{x}$ = 34.8 m) during August (Map 54). In 95% of the sightings of this species, water depths were less than 100 m (Table 20). The unidentified turtles seen in NFLA (Map 55) ranged in waters 30 to 130 m in depth ($\bar{x}$ = 58.9 m) with 94% of all sightings in waters less than 100 m deep. The single leatherback sighted in NFLA during August was in water 30 to 40 m deep (Map 54).

Turtles in SFLA

Loggerhead turtles occurred in waters with depths of less than 91 m ($\bar{x}$ = 41.7 m) during August (Map 56). In 80% of the sightings, water depths were less than 50 m (Table 20). Unidentified turtles were observed in waters averaging 38.8 m in depth with a

Table 19. Depth and distance from shore comparisons for turtles sighted in Texas survey subunits.

Species	Survey subunit	Season	Water depth (m)	Distance from shore (km)
Kemp's ridley turtle	STEX	November	31	24
Kemp's ridley turtle	STEX	August	31	29
Kemp's ridley turtle	STEX	August	409	100
Loggerhead turtle	NTEX	August	21	20
Unidentified turtle	STEX	August	73	76
Unidentified turtle	NTEX	August	71	93
Non-ridley turtle	NTEX	November	127	93

Table 20. The distribution of loggerhead turtles sighted in Florida during August in relation to water depth.

Water depth (m)	NFLA		SFLA	
	No.	%	No.	%
10	1	1.5	2	3.9
20	15	22.4	6	11.8
30	12	17.9	12	23.5
40	5	7.5	17	33.3
50	6	9.0	4	7.8
60	4	6.0	2	3.9
70	4	6.0	3	5.9
80	5	7.5	3	5.9
90	6	9.0	2	3.9
100	6	9.0	0	0.0
110	1	1.5	0	0.0
120	0	0.0	0	0.0
130	1	1.5	0	0.0
200	1	1.5	0	0.0

maximum depth of 120 m (Map 57). For 84% of these observed groups, water depth was also less than 50 m. The two leatherback turtles seen during August were in water with a depth of 50 to 60 m (Map 58). The four green turtles recorded in SFLA during August were in waters 20 to 50 m deep ($\bar{x}$ = 45.0 m).

During November loggerheads were most common (80%) in nearshore waters (i.e. 0 to 30 m deep) in the eastern and northeastern extremes of the survey subunit. Some individuals, sighted in deeper waters (30 to 70 m) near the southwestern corner of the subunit may have been transients between the Florida coast and the Dry Tortugas.

GROUP SIZE

Mammals

The mean group size for mammal species apparently varied on a geographic and seasonal basis. Tables 21 through 24 list the mean group sizes of mammals seen in the various survey subunits.

The mean group size for bottlenose dolphins ($\bar{x}$ = 17.4 individuals per group) was higher in NTEX during August than in all other subunits and seasons. Mean group sizes for other subunits ranged from 3.2 to 11.7. Group sizes of bottlenose dolphins, and to a lesser extent other dolphins, tended to be lower in November than in August.

Saddleback dolphins and those of the genus Stenella tended to occur in large groups whereas other mammals were in noticeably smaller groups. During August striped dolphins in the NFLA subunit were observed in larger groups ($\bar{x}$ =32.4) than those in SFLA ($\bar{x}$ = 1.4).

The only sperm whales observed were seen in the western Gulf of Mexico during August. A pod of three adults and one young was seen in NTEX, and a single adult was noted in STEX.

Birds

The group sizes of birds varied widely depending on the species, subunit, and season. Some species such as gulls and shearwaters tend to feed in large groups when food is abundant or concentrated in patches. Group sizes for Cory's shearwaters and unidentified gulls were noticeably high in STEX during August. Black terns also occurred in large groups ($\bar{x}$ = 38.9) in STEX during August. Shearwaters and black terns were not observed during November surveys in STEX. The mean group size of royal terns did not increase when the number of sightings quadrupled in NFLA from August to November, but did increase in SFLA during the same period. Many species of birds move and feed as solitary individuals and in small groups but accounted for a high number of sightings. Tables 25 through 28 list the mean group sizes of birds seen in the various survey subunits.

The relationship of group size to individual environmental variables such as fish schools, sargassum windrows, and ocean depth is an important investigative perspective that requires repeated observations over a seasonal time span. Additional analyses of group size data are essential to estimation of abundance and movements.

Table 21. Summary of mean group sizes for mammals in STEX. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Sperm whale	1.0	1	0.0	0
Unidentified whale	2.0	1	0.0	0
Beaked whale	3.0	1	0.0	0
Bottlenose dolphin	0.0	0	11.7	10
Short-finned pilot whale	13.0	1	3.0	1
Spotted dolphin	50.0	2	0.0	0
Striped dolphin	3.0	1	0.0	0
Stenella sp.	24.0	5	0.0	0
Saddleback dolphin	50.0	1	0.0	0
Unidentified dolphin	18.5	8	5.7	3

Table 22. Summary of mean group sizes for mammals in NTEX. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Sperm whale	4.0	1	0.0	0
Unidentified whale	0.0	0	1.0	1
Bottlenose dolphin	17.4	10	3.7	7
Spinner dolphin	150.0	1	0.0	0
Spotted dolphin	17.5	2	0.0	0
Striped dolphin	13.0	1	0.0	0
Stenella sp.	6.0	2	0.0	0
Saddleback dolphin	30.0	1	0.0	0
Unidentified dolphin	3.8	10	3.0	1

Table 23. Summary of mean group sizes for mammals in NFLA. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Unidentified whale	1.0	1	0.0	0
Bottlenose dolphin	3.5	14	5.4	10
Spotted dolphin	1.0	1	0.0	0
Striped dolphin	32.4	5	0.0	0
Stenella sp.	3.5	2	11.0	3
Saddleback dolphin	6.0	3	0.0	0
Unidentified dolphin	0.0	0	2.8	4

Table 24. Summary of mean group sizes for mammals in SFLA. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Bottlenose dolphin	3.2	5	2.5	10
Striped dolphin	1.4	9	5.0	1
Stenella sp.	10.5	2	3.4	5
Unidentified dolphin	1.3	18	2.4	11
Caribbean manatee	0.0	0	3.0	1

Table 25. Summary of mean group sizes for birds in STEX. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Cory's shearwater	17.4	9	0.0	0
Audubon's shearwater	1.0	2	0.0	0
Unidentified shearwater	1.2	6	0.0	0
Storm-petrel	0.0	0	1.0	1
Tropicbird	1.0	1	0.0	0
Brown pelican	0.0	0	1.0	1
Masked booby	1.5	2	0.0	0
Brown booby	1.0	1	0.0	0
Northern gannet	1.0	3	0.0	0
Cormorant	0.0	0	23.3	15
Phalarope	1.0	2	0.0	0
Herring gull	0.0	0	2.0	26
Laughing gull	1.0	5	0.0	0
Unidentified gull	53.5	2	19.2	19
Royal tern	9.4	14	10.5	66
Unidentified pale tern	4.0	18	1.0	1
Sooty tern	2.0	3	0.0	0
Bridled tern	1.0	1	0.0	0
Black tern	38.9	12	0.0	0
Unidentified dark tern	1.5	13	1.5	2
Unidentified tern	7.6	20	5.8	55

Table 26. Summary of mean group sizes for birds in NTEX. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Cory's shearwater	1.5	4	0.0	0
Storm-petrel	1.0	2	0.0	0
Masked booby	2.0	4	0.0	0
Magnificent frigatebird	6.3	3	0.0	0
Phalarope	1.0	3	1.0	1
Herring gull	0.0	0	9.7	38
Laughing gull	8.4	21	1.0	2
Unidentified gull	6.2	6	3.6	10
Common tern group	2.0	2	0.0	0
Least tern	1.0	1	0.0	0
Royal tern	4.6	75	1.3	26
Sandwich tern	1.0	1	0.0	0
Unidentified pale tern	3.1	30	0.0	0
Sooty tern	1.0	1	0.0	0
Black tern	2.4	5	0.0	0
Unidentified dark tern	0.0	0	1.0	1
Unidentified tern	1.3	21	42.0	3
Unidentified bird	1.0	7	1.0	1
Unidentified white bird	5.5	2	5.5	2

Table 27. Summary of mean group sizes for birds in NFLA. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Brown pelican	9.1	38	3.3	41
Northern gannet	1.0	1	0.0	0
Cormorant	7.2	6	2.0	2
Magnificent frigatebird	1.2	21	1.0	2
Phalarope	0.0	0	7.0	2
Herring gull	0.0	0	2.3	4
Laughing gull	2.0	1	3.3	34
Unidentified gull	1.0	1	3.7	16
Bridled tern	1.0	5	0.0	0
Royal tern	3.7	64	2.5	288
Sandwich tern	1.0	2	0.0	0
Unidentified dark tern	2.8	4	0.0	0
Unidentified pale tern	1.0	5	0.0	0
Unidentified tern	2.5	65	0.0	0

Table 28. Summary of mean group sizes for birds in SFLA. n = number of groups sighted.

Species	August		November	
	x	n	x	n
Common loon	0.0	0	0.0	0
Cory's shearwater	1.0	1	1.0	1
Storm-petrel	1.0	1	0.0	0
Brown pelican	1.0	4	1.7	11
Magnificent frigatebird	3.3	19	1.0	11
Herring gull	0.0	0	1.0	1
Laughing gull	1.0	1	7.2	20
Unidentified gull	1.3	3	1.0	1
Common tern group	1.0	3	0.0	0
Sooty tern	1.0	2	0.0	0
Bridled tern	1.0	7	0.0	0
Least tern	1.0	1	0.0	0
Royal tern	1.0	13	10.6	443
Sandwich tern	1.0	1	1.0	1
Black tern	1.0	1	1.0	3
Unidentified dark tern	1.0	4	0.0	0
Unidentified pale tern	1.0	3	1.0	2
Unidentified tern	1.0	12	6.9	120

ASSOCIATION OF MAMMALS AND BIRDS WITH VESSELS

Table 29 shows that the number of surface vessels seen during the Pilot Study followed no seasonal pattern. However, commercial fishing/shrimp boats tended to aggregate within waters less than 50 m deep. Ships, including tankers, freighters, and crew boats, are less likely to distort normal feeding patterns for mammals and birds because they offer less food. Such craft tended to be less clustered in their distribution and were sighted in waters of all depths. Thus, any effect of ships on observations might be present in any part of the survey subunits, whereas fishing/shrimp boats might effect only observations made in relatively shallower waters.

The association of mammals and birds with fishing boats was common in Texas, but very rare in Florida. During August organisms were found in proximity to fishing boats 9 times in STEX and 15 times in NTEX. One of the nine occurrences in STEX involved an unidentified Stenella; the others involved terns and gulls. The 15 occurrences in NTEX included 5 sightings of bottlenose dolphins around anchored shrimp boats, while terns and gulls were sighted around boats the other 10 times. The association of bottlenose dolphins with boats is well known to the fishermen in the area off Matagorda Island (J. Gruber, Department of Wildlife and Fisheries Sciences, Texas A & M University, College Station, Texas; pers. comm.).

During November we found mammals and/or birds in proximity to fishing boats 11 times in STEX and 6 times in NTEX. The 11 sightings in STEX included one sighting of a group of three bottlenose dolphins; the rest involved gulls and terns. The six sightings in NTEX were all of birds, mostly herring gulls and unidentified terns.

We found only one case of an association with a fishing boat in our four Florida surveys. The single observation was of a pair of unidentified birds with a boat in NFLA during November.

Table. 29. The number of surface vessels seen during aerial surveys.

Survey subunit	August	November
STEX	67	25
NTEX	78	105
NFLA	67	52
SFLA	33	36

MULTIPLE SPECIES ASSOCIATIONS

During the August and November surveys, a number of multispecies associations were observed which involved birds, mammals, and/or fish. Most of the associations seemed to involve birds and sometimes mammals feeding on fish schools. The more discrete and intensive associations are described below.

The most notable associations occurred on 20, 21, and 22 August in the STEX subunit near the continental shelf margin (70 to 100 km offshore). The first of these associations was spotted at a distance of over 2 km off the survey tract and appeared as a white "boil" on the ocean where organisms were breaking the surface in a tight group. At closer range a school of fast-swimming fish, apparently feeding on smaller organisms, was observed. It was visually estimated that the fish responsible for the surface disturbances were approximately a half meter in length. They attracted a variety of birds, mammals, and sharks. The animals grouped in the vicinity included 10 to 15 short-finned pilot whales, 50 to 60 spotted dolphins in a tight ball, a flock of 75 to 100 Cory's shearwaters, the only brown booby seen during the surveys, a variety of sharks ranging in size from about 1.5 m to over 4 m in length, and a whale shark (Rhincodon typus) estimated at 13 to 16 m in length. In the course of the three day survey, approximately 20 of these disturbances were seen. The close proximity of some disturbances to one another occasionally presented difficulty in describing the activity as single or multiple associations. Only the first of the associations contained mammals, but sharks up to 5 m long and birds were present in most. On 21 August approximately 10 groups were observed, 3 of which included single whale sharks and some of which included Cory's shearwaters, sooty terns, and black terns. Eight groups observed on 22 August included at least three and possibly five whale sharks, sooty and black terns, a masked booby, and Cory's shearwaters.

The fish schools would periodically surface, forming patches of white, broken water. The sharks generally stayed below the surface. The whale sharks occasionally were seen within the fish schools, but more frequently were 10 to 50 m from them and usually 2 m or more below the surface.

On 24 August in the NTEX subunit an association involving sperm whales and dolphins was observed. At a position approximately 210 km offshore a group of three adult sperm whales with one calf was observed. The three adults were similar in size, suggesting that they were all females. While circling the whales, a group of about 20 dolphins (probably Stenella; possibly spotted dolphins, S. plagiodon) was sighted at least 0.5 km from the whales. The dolphins swam toward and around the whales and gathered behind their flukes. The whales sounded, leaving the dolphins at the surface.

Also on 24 August, a flock of birds was observed about 65 km off the coast of the NTEX subunit. It included three frigatebirds and nine royal terns, and was joined briefly by one masked booby. The birds were circling over a submerged globular object nearly a meter in diameter, but were not seen to feed. As the plane circled the flock, a group of about 10 bottlenose dolphins was observed swimming toward the flock. The dolphins appeared to be attracted to the bird flock.

During November flocks of birds, composed primarily of royal terns, were seen in all subunits. These mixed flocks were most abundant and were largest in SFLA where groups of several hundred birds were seen. In SFLA laughing gulls had joined several of the tern flocks and in NTEX herring gulls were prominent in some. The SFLA flocks were feeding over schools of baitfish that were rippling the surface, while some of the NTEX flocks gathered around fishing boats.

On 15 November in the NFLA subunit, a dusky shark (Carcharhinus obscurus) and six bottlenose dolphins were observed attacking a 10- x 20-m school of mullet (Mugil sp.) approximately 25 km offshore. The porpoises were feeding along the trailing edge of the school while the shark cut through at right angles. No interaction was observed between the shark and porpoises.

Smaller aggregations involving frigatebirds and other bird species were frequently encountered in proximity to dolphins. The significance of such associations is not apparent at present. Additional data are needed on biological associations before assessing their roles in marine systems.

DENSITY ESTIMATES

To estimate densities of individual animal taxa, the data were examined using the Linetran statistical package. For purposes of the Pilot Study, which is subject to data limitations detailed previously, density calculations have been limited to the taxa most commonly sighted within a single survey subunit and season. Calculations for other taxa can be made in subsequent studies by combining data from adjacent areas or proximal seasonal samples.

The Linetran statistical package includes both parametric and nonparametric estimators. For the Pilot Study data, only the nonparametric estimators are appropriate due to the reduced visibility of the area immediately below the survey aircraft (i.e., the transect line). This limitation will not be operant for data collected from an aircraft with maximal forward and downward visibility allowing inspection of transect line (Beechcraft AT-11 or similar aircraft).

Estimates were calculated using the ungrouped splined method of Gates (1979). This technique attempts to compensate for the truncated data set resulting from the blind area beneath the aircraft, and for the variable distribution of sightings in relation to the transect line. The algorithm was selected after consideration of 14 estimators available in the Linetran package.

The maximum perpendicular distance for sightings in NFLA varied from 234 to 1,326 m with a mean for all species of 686 m. This is judged to be an overestimate of this distance due to the numerous sightings of birds above the water's surface, which affects the sighting angle used to compute distance.

The maximum observable distance for each taxon is important to density calculations. For inconspicuous species the effective observation distance may be limited to 200 m, whereas for others it may exceed 1 km. In line transect computations, as opposed to strip transect methods, the area considered to have been surveyed is relative to the distance at which sightings were made. Consequently, the percent coverage of the subunit varies with the observability of the taxa. For example, the maximum observation distances for bottlenose dolphins, royal terns, and unidentified terns in August-NFLA flights were 279, 872, and 1,326 m, respectively. These distances suggest that terns, which are more conspicuous because of their coloration and ability to fly, are more detectable than bottlenose dolphins. Terns can be seen from greater distances, although at extreme distances they are often not identified to species. Thus, the area covered with respect to terns is significantly greater than the area covered for bottlenose dolphins. The percent aerial coverage for August-NFLA was: bottlenose dolphins, 4.5%; royal terns, 14%; and unidentified terns, 21.5%.

A comparison of the total number of individuals, the maximum observation distance, and the estimated density for the example taxa in Table 30 suggests several relationships relevant to evaluating the data. First, the taxa for which the most sightings were made are not necessarily judged to be the most abundant. Density estimates necessarily compensate for the observability of the animal away from the transect line. Those animals which are viewed at large distances must be seen more often than those with short observation distances. For example, the larger number of royal terns (281) seen in STEX during November resulted in a density estimate of 0.36 birds/km^2, whereas the smaller number (31) seen during August yielded an estimate of 0.20 birds/km^2. The 186 royal terns seen in NTEX-August surveys resulted in a density estimate only twice as large as the density estimate resulting from the 31 royal terns sighted in NTEX during November. In the first case, the aggregation of birds during November allowed detection at greater distances, and thus facilitated the greater area to be surveyed. Part of the increase in the total number of birds sighted was a result of increased area and part was the result of increased abundance. It may be significant that the decrease in royal terns in NTEX during November was accompanied by an increase in the species in STEX. A similar increase is seen in the density of royal terns in SFLA during November (Table 31); the change in NFLA is less pronounced (Table 32). This possibly suggests that the new birds in SFLA during November were arriving from areas other than NFLA.

Comparison of seasonal and geographic variation in other density estimates for Florida subunits (Tables 31 and 32) allows several trends to be defined. Laughing gulls were twice as abundant in SFLA as in NFLA during November. Loggerhead turtles were only slightly more abundant in SFLA than in NFLA during August. However, loggerhead density in NFLA during November was below the number needed for density calculations, whereas they were only slightly less abundant during November.

The brown pelican, a bird without pronounced seasonal movements, had similar density estimates in NFLA during November and August. Density estimates for royal terns were similar during the two surveys in NFLA (Table 31). In SFLA, higher November concentrations of royal terns are suggested by both absolute numbers and density estimates (Table 32).

The estimates of densities available from the Pilot Study remain to be confirmed by repeated measurements and increased sample sizes. Confidence limits for most estimates are wide; however, these limits will be narrower when estimates spanning an increased number of observations are available. As the ecological zonation of each species is defined it will be important to calculate densities in appropriate portions of the subunits rather than considering a generalized distribution throughout the study area.

Future studies will also allow the determination of seasonal trends by allowing comparison of an entire sequence of estimates instead of merely two points in time.

Table 30. Density statistics for selected species in seasonal samples.

Species	Number sighted	Density (individuals/km^2)	Variance	Upper 95% confidence limit	Maximum sighting distance (m)
			August STEX		
Royal tern	31	0.20	0.04	2.82	349
			November STEX		
Royal tern	281	0.36	0.03	0.84	872
Bottlenose dolphin	102	0.55	0.10	1.92	1,069
			August NTEX		
Royal tern	186	0.39	0.15	1.63	872
Bottlenose dolphin	28	2.74		10.22	334
			November NTEX		
Royal tern	31	0.18	0.00	0.18	1,069

Table 31. Density statistics for selected species in the NFLA subunit.

Species	Number sighted	Density (individuals/km^2)	Variance	Upper 95% confidence limit	Maximum sighting distance (m)
		August			
Bottlenose dolphin	31	2.89	2.39	22.55	279
Striped dolphin	67	0.05	6.14×10^{-6}	0.23	234
Brown pelican	35	0.19	0.03	2.65	872
Royal tern	88	0.19	0.03	2.65	872
Unidentified tern	116	0.38	0.14	2.04	1,326
Loggerhead turtle	34	0.19	0.03	2.65	501
		November			
Brown pelican	36	0.18	0.03	2.56	501
Laughing gull	68	0.18	0.03	2.56	349
Unidentified gull	44	1.12	0.13	5.87	1,069
Royal tern	564	0.18	0.17	1.12	663
Unidentified tern	242	0.37	0.05	1.01	501

Table 32. Density statistics for selected species in the SFLA subunit.

Species	Number sighted	Density (individuals/km^2)	Variance	Upper 95% confidence limit	Maximum sighting distance (m)
		August			
Striped dolphin	106	5.00	0.16	6.72	642
Bridled tern	25	0.20	3.24	23.10	349
Royal tern	58	0.40	0.02	0.40	349
Loggerhead turtle	47	0.20	4.00×10^{-2}	2.74	872
		November			
Laughing gull	137	0.37	2.71×10^{-2}	1.08	349
Royal tern	3,760	0.56	0.06	1.12	1,336
Unidentified tern	707	0.18	3.49×10^{-2}	0.60	1,326
Loggerhead turtle	30	0.18	0.00	0.18	501

Similarly, the larger geographic area and ability to sample intervening areas will facilitate identification of movement patterns and their relative significance in local and overall populations.

SEA SURFACE TEMPERATURES

The sea surface temperatures recorded during the Pilot Study are comparable to winter and summer patterns previously known for the Gulf of Mexico (Leipper 1954). During August sea surface temperatures were warmer nearshore, decreasing in a seaward direction, but overall they remained quite uniform. For example, the mean temperatures recorded for each s~ecies observed in STEX ranged from 28.0° to 29.2° C. The mean temperatures observed in NTEX were sliohtly lower (27.5° to 28.6° C), as would be expected moving from south to north in the western Gulf of Mexico. In both Texas subunits during August, certain birds only seasonally present (i.e., absent in November) were concentrated in the areas of lowest sea surface temperatures. These species included sooty terns and masked boobies. The latter species, a diving bird poorly known in Texas waters, was reported to be one of the most conspicuously effected bird species during the Ixtoc oil spill (NOAA news briefing 1979).

During November temperatures were not only lower, but the temperature gradient from shore to seaward was reversed in relation to August. Temperature gradients were steepest off NTEX and NFLA, which may explain the absence or low numbers of marine mammals during November surveys in these subunits. Whether the scarcity of bottlenose dolphins in STEX during August and in NTEX during November represents seasonal movements in response to temperatures remains to be confirmed, but temperatures where these dolphins were observed in Florida during both seasons were comparable to those in Texas waters. Movements into and out of coastal lagoons also may account for the intermittent absence of bottlenose dolphins in Texas survey subunits (Schmidly and Shane 1978).

OBSERVER BIAS

The quantification of observations by independent observers on opposite sides of the aircraft depends upon the comparability of sighting frequencies. Visual scan patterns, observer confidence, and individual reaction times are all important factors, but their effects can be minimized by appropriate training. A matched pair of observers simultaneously flying over the same geographic area would be expected to record approximately equal numbers of sightings and similar faunal compositions. Some deviation from a 50% frequency would be explained by sampling error and random deviations. Figure 5 charts the deviation of the observer pairs from the expected 50% sighting frequency. Only in two sampling periods does the deviation reach 15%. The samples in Figure 5 are arranged in chronological order from left to right and a trend toward reduction of the deviation is apparent as the observer team gained experience and methods were improved.

This trend is probably explained by added observer experience and the improvement of observer methods during the Pilot Study. No discernible differences

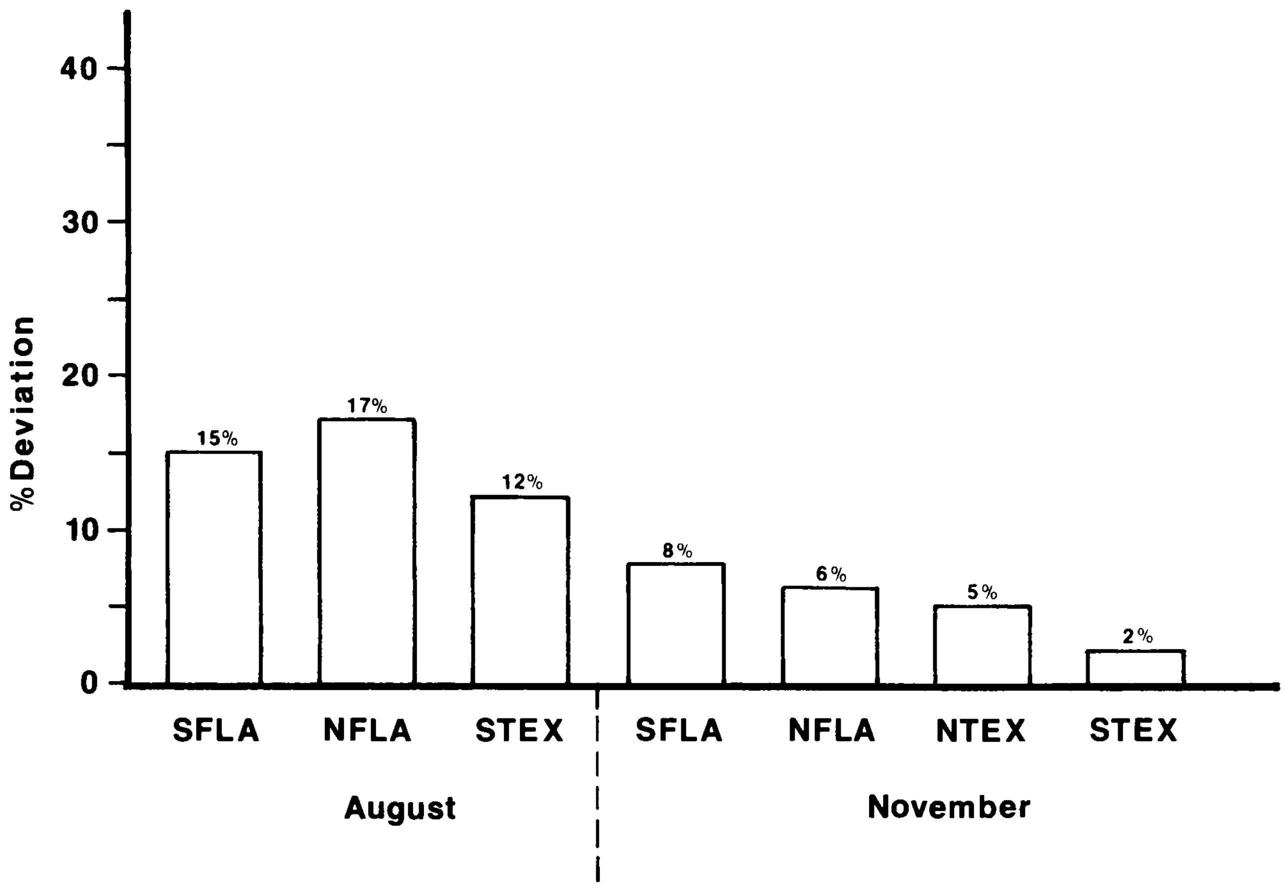


Figure 5. Deviation in percent of sightings by paired aerial observers.

were noted in the species cited by individual observers of the matched pairs. All observers participated in training sessions involving ground and aerial identification methods.

ALTITUDINAL EFFECTS

Due to the great disparity in size, coloration, and location of various species, it is important to consider the effect of the elevation of the aircraft on the detection and identification of individuals and groups of organisms. Flights were conducted at 91 and 228 m in equal frequency in order to evaluate altitudinal effects and maximize data accuracy for all groups.

The total number of groups sighted during low (91 m) and high (228 m) flights are compared by season in Tables 33 through 41. In three of the eight seasonal samples (37.5%) more terns were seen during low flights than during higher flights. The number of turtles seen in low flights exceeded that of higher flights in three of the eight samples, and approached that of higher flights by 95% in two others. More mammals were seen in four of the eight seasonal samples (50%) at low altitudes. Thus, in terms of total numbers of groups seen, flight altitude may have only a slight effect on detectability depending upon the group concerned.

Because of the small size and fast movements of birds, it was hypothesized that low altitudes would be necessary to allow identification. When the number of birds not identified to exact species is compared to the total number of birds sighted in a high or low sample (Table 42) an increase in unidentified birds at high altitudes is evident in seven of the eight seasonal samples. Thus, even if detectability of birds remains the same at both survey altitudes, the identifiability may be reduced at higher altitudes.

In part, differences in detectability and identification may be related to the visual scan techniques employed by the aerial observer. At higher elevations a broader field of view is available which requires more deliberate eye and head movement. In fact, this increase in area scanned affords less time for detection of animals in any one location. However, because of the relatively slower speed of the aircraft in relation to the ocean's surface, once an organism is detected it remains in view longer, giving the observer more time to identify it. Such a time interval is in part nullified by the greater distance (both horizontal and vertical increases are possible) from which the animal is viewed. In practice, identifications of turtles, mammals, and most birds are often made instantaneously, but deviation from the flight path to confirm identification is necessary more often during high flights than during low ones.

At present the practice of employing an equal number of flights at 91- and 228-m altitude appears to be justified in providing opportunities to maximize detection and identification of organisms of diverse sizes, habits, and group composition. It is probable that alternating flights at low altitudes serve to reinforce indentifications at higher altitudes. This would increase data quality at both altitudes.

Actual effect of altitude is complex, with increased sightings often accompanied by decreased identifiability. For example, in November-NFLA surveys only 10% of all birds sighted during flights at 91 m were not identified to species whereas 34% of those sighted in flights at 228 m were not identified to species.

Table 33. The number of sightings made at low (91 m) and high (228 m) altitudes in STEX during August.

Species	91 m	228 m
Shearwaters	5	6
Dark terns	9	17
Pale terns	20	13
Unidentified terns	10	10
Boobies, gannets, and tropicbirds	4	2
Gulls	4	3
Phalaropes and storm-petrels	4	2
Frigatebirds and pelicans	1	0
Total birds	60	60
Total turtles	3	0
Total mammals	12	8
Total unidentified birds	33	38

Table 34. The number of sightings made at low (91 m) and high (228 m) altitudes in NTEX during August.

Species	91 m	228 m
Shearwaters	2	3
Dark terns	6	1
Pale terns	41	62
Unidentified terns	7	14
Boobies, gannets, and tropicbirds	1	4
Gulls	9	12
Phalaropes and storm-petrels	4	1
Frigatebirds and pelicans	0	3
Total birds	72	107
Total turtles	1	1
Total mammals	5	15
Total unidentified birds	24	48

Table 35. The number of sightings made at low (91 m) and high (228 m) altitudes in STEX during November.

Species	91 m	228 m
Shearwaters	0	0
Dark terns	2	0
Pale terns	29	37
Unidentified terns	21	34
Boobies, gannets, and tropicbirds	1	0
Gulls	31	14
Phalaropes and storm-petrels	0	0
Frigatebirds and pelicans	0	1
Total birds	97	92
Total turtles	0	1
Total mammals	7	5
Total unidentified birds	54	42

Table 36. The number of sightings made at low (91 m) and high (228 m) altitudes in NTEX during November.

Species	91 m	228 m
Shearwaters	0	0
Dark terns	1	1
Pale terns	17	9
Unidentified terns	0	1
Boobies, gannets, and tropicbirds	0	0
Gulls	21	29
Phalaropes and storm-petrels	0	1
Frigatebirds and pelicans	0	0
Total birds	41	42
Total turtles	1	1
Total mammals	3	5
Total unidentified birds	8	12

Table 37. The number of sightings made at low (91 m) and high (228 m) altitudes in NFLA during August.

Species	91 m	228 m
Shearwaters	0	0
Dark terns	3	0
Pale terns	48	30
Unidentified terns	12	50
Boobies, gannets, and tropicbirds	1	0
Gulls	2	0
Phalaropes and storm-petrels	0	0
Frigatebirds and pelicans	31	26
Total birds	99	111
Total turtles	41	43
Total mammals	9	17
Total unidentified birds	20	58

Table 38. The number of sightings made at low (91 m) and high (228 m) altitudes in SFLA during August.

Species	91 m	228 m
Shearwaters	1	0
Dark terns	1	6
Pale terns	19	8
Unidentified terns	5	7
Boobies, gannets, and tropicbirds	0	0
Gulls	2	2
Phalaropes and storm-petrels	2	1
Frigatebirds and pelicans	9	12
Total birds	45	40
Total turtles	35	53
Total mammals	8	24
Total unidentified birds	11	19

Table 39. The number of sightings made at low (91 m) and high (228 m) altitudes in NFLA during November.

Species	91 m	228 m
Shearwaters	0	0
Dark terns	0	0
Pale terns	162	122
Unidentified terns	19	27
Boobies, gannets, and tropicbirds	0	0
Gulls	48	6
Phalaropes and storm-petrels	2	0
Frigatebirds and pelicans	30	13
Total birds	269	174
Total turtles	16	18
Total mammals	9	5
Total unidentified birds	42	34

Table 40. The number of sightings made at low (91 m) and high (228 m) altitudes in SFLA during November.

Species	91 m	228 m
Shearwaters	1	0
Dark terns	0	3
Pale terns	240	203
Unidentified terns	17	102
Boobies, gannets, and tropicbirds	0	0
Gulls	17	2
Phalaropes and storm-petrels	0	0
Frigatebirds and pelicans	11	10
Total birds	301	333
Total turtles	18	19
Total mammals	9	9
Total unidentified birds	31	113

Table 41. The number of groups seen in low flights expressed as a percentage of those seen in corresponding high flights.

Species	August				November			
	STEX	NTEX	NFLA	SFLA	STEX	NTEX	NFLA	SFLA
Terns	98	70	78	119	73	163	121	84
All birds	100	67	89	112	105	98	154	90
Turtles	—	100	95	70	0	100	89	95
Mammals	150	33	52	33	140	60	180	100
Unidentified birds	87	50	34	58	128	66	123	27

Table 42. The number of unidentified bird sightings expressed as a percentage of total bird sightings made during low (91 m) and high (228 m) flights.

Survey subunit	August		November	
	91 m	228 m	91 m	228 m
STEX	55.0	63.3	55.7	45.7
NTEX	33.3	44.9	19.5	28.6
NFLA	20.2	52.3	15.6	19.5
SFLA	24.4	47.5	10.3	33.9

BEAUFORT FORCE

The ocean surface forms a vast background against which and occasionally through which observations are made. The sea surface can have an appreciable effect on the detectability and observability of organisms depending upon waves related to wind, rain, and depth, as well as other factors. Sea surface state was recorded using the Beaufort Force Index. Table 43 details the percentage of observations made under Beaufort states 1 through 4. Although flights were terminated any time sea states stabilized at or above 4, a few observations were made under these conditions in the vicinity of local thunderstorms. States 1 and 2 are characterized by a smooth water surface without waves breaking. State 3 includes conditions with scattered white caps which provide some visual noise for aerial observers and may reduce detectability of those organisms of small size, those with white coloration, and animals which have a low profile in the water. The percentage of observations made at sea states of 3 or 4, summarized in Table 43, clearly shows that sea states during November flights were higher than those during August except in STEX. The future collection of seasonal data over the entire annual cycle and at more frequent intervals is necessary to allow rigid analysis of the effect of sea state on quantitative estimation of occurrence and abundance.

GLARE

The amount of reflected sunlight from the ocean's surface has a significant effect on the observer's ability to detect and observe the organisms of interest. Glare can severely impair otherwise ideal conditions, even calm sea states. Since the location of the survey aircraft, the position of the sun, and the intensity of the sunlight are dynamic factors, the effect of glare is most easily determined by comparing simultaneous sighting records made from opposite sides of the aircraft. In the Cessna Skymaster used in the Pilot Study, observers utilized observation windows on opposite sides of the plane and glare, when present, was usually on one side of the aircraft or the other. Flight paths at three survey subunits (STEX, NFLA, and SFLA) were in an east-west direction and comparison of observations on the north and south sides of the aircraft allow glare to be considered independent of subjective estimates of the intensity of the glare present. In those subunits flown on east-west axes, observations made from the north and south sides of the aircraft were comparable during August, but November observations made from the south side of the aircraft were markedly lower than those made from the north (Table 44).

In the NTEX subunit, which was surveyed on a northwest-southeast axis, seasonal differences are less obvious; but observation totals on the southwest side were consistently lower than comparable sightings on the opposite side (Table 45). In fact, both sides of transect line were affected by glare but it was more severe on the southwest side. Since these results span flights in both landward and seaward directions and include systematic rotation of observers and their positions, these factors cannot be used to explain differences observed.

As suggested above, the percentage of observations recorded on the side of the aircraft with glare will be significantly lower in winter months than in summer. Table 46 summarizes the expected effects on glare vs. nonglare situations. Pending confirmation of these trends, it may be necessary to adjust abundance estimates to compensate for glare factors.

Table 43. Percentage of total observations made at each Beaufort sea state.

Survey subunit	Season	Sea states				
		1	2	3	4	3
STEX	August	2.0	51.3	44.0	2.7	46.7
STEX	November	27.8	37.1	33.2	1.9	35.1
NTEX	August	61.2	34.2	3.2	1.4	4.6
NTEX	November	21.4	58.1	20.4	0.0	20.4
NFLA	August	41.7	57.1	1.2	0.0	1.2
NFLA	November	0.0	50.7	49.2	0.0	49.2
SFLA	August	45.8	54.2	0.0	0.0	0.0
SFLA	November	2.1	61.5	36.1	0.03	36.1

Table 44. Number of observations made from each side of the aircraft during surveys flown on east-west axes.

Survey subunit	Season	Observation port	
		S	N
STEX	August	34	37
STEX	November	28	65
NFLA	August	45	45
NFLA	November	63	137
SFLA	August	36	40
SFLA	November	89	147

Table 45. Number of observations made from each side of the aircraft during surveys flown on northwest-southeast axes.

Survey subunit	Season	Observation port	
		SW	NE
NTEX	August	43	64
NTEX	November	26	38

Table 46. Ratios of south/north (southwest/northeast for NTEX) observations for all groups.

Survey subunit	Season	Ratio
STEX	August	0.91
STEX	November	0.43
NTEX	August	0.68
NTEX	November	0.67
NFLA	August	1.00
NFLA	November	0.45
SFLA	August	0.90
SFLA	November	0.61

CONCLUSIONS

Aerial surveys in the Gulf of Mexico completed during the Pilot Study provided unique data on the distribution, relative abundance, and ecology of 13 mammal, 35 bird, and 5 turtle taxa, including several endangered and threatened species. Precise locational and environmental data on approximately 3,000 sightings allowed formation of a preliminary data base for multidimensional analyses. Once data cover an adequate time period, analyses of species composition, temporal and spatial distributions, movements, areas of special significance, and relative abundance will be possible. The combined effect of the small number of samples (2) and the interval between samples (3 months) precludes such analyses at present. Knowledge of OCS areas must be based on more frequent samples conducted over annual cycles.

The results of the present study indicate that large voids in the knowledge of endangered and vulnerable animals in OCS areas can be filled by future studies. Preliminary maps of the distribution of taxa within the study area illustrate relationships and zonation within surveyed areas and adjacent waters. These maps, although based on observations over a short time, illustrate distributions on a more detailed scale than previously available.

A greater number of mammal species, including several whales, were found off Texas than off western Florida. This may reflect the narrower continental shelf of Texas waters. The importance of the waters off of southern Texas as marine mammal habitats was illustrated by the frequency of sightings in this area. The discovery of the endangered sperm whale in both Texas survey subunits is remarkable in providing the first observations of living individuals of this species in the western Gulf of Mexico in several decades.

Seasonal movements of terns, shearwaters, and several dolphin taxa are evident. Royal terns and other species were noted to extend further offshore over deeper waters in November than in August. Understanding of these patterns would be important in evaluating of oil and gas impacts on these and other migratory species.

More turtle species and a higher density of turtles were observed in Florida than in Texas during both survey periods. Loggerhead turtles were exceptionally abundant in Florida waters. Some evidence exists for long-distance movements of loggerhead turtles from the western Florida coast to the lower Keys and Dry Tortugas. Magnificent frigatebirds and other birds appear to move along similar routes. Of the Stenella species encountered, spotted dolphins were most conspicuous in Texas waters. Striped dolphins were in Florida waters on a seasonal basis.

Although regular seasonal migrations are well documented for birds, data available from this study suggest that migration patterns for mammals and turtles are poorly understood. In all survey subunits, more mammals and turtles were observed in August than in November. Some taxa which were conspicuous in one season were not observed during the other. The geographic limits and seasonality of these movements are not known at present.

Distinct patterns were noted for the spatial occurrence of birds, mammals, and turtles in relation to water depth and distance from shore. These data are particularly pertinent to consideration of OCS development.

The results of the Pilot Study illustrate the dynamic complexity of marine vertebrate faunas. The study provided the basis for development, testing, and implementation of a study plan which encompasses the collection, analysis, and interpretation of data within OCS areas. The data base of ultimate utility must encompass seasonal, geographical, environmental, and annual variation to allow detailed analyses. Such information is critically important to the conservation and management of endangered and vulnerable marine animals and the OCS planning.

Many trends and conclusions are apparent in the data presented herein. However, the limitations of the data set must be considered. Two comparable surveys were made on a three month cycle. In the absence of data collected on a more frequent schedule and encompassing the entire annual cycle, correlations with seasonal, geographic, and environmental factors are difficult to distinguish from superfluous associations. The present discussion of the Pilot Study results was prepared to show the depth and complexity of the investigation. It also serves to elucidate the value of data on important vertebrate species to OCS planning and development, and the need for long-term studies.

Aerial surveys are dependent upon qualified observers and statistically documented data. The quality of the observers improves with experience and time, and consequently, so does the data. In part, informational gain is additive with all previous information relevant to the interpretations of current data. As a consequence, further studies in the Gulf of Mexico and Atlantic Ocean off of the southeastern United States promise to contribute significantly to the understanding of the animals studied and their ecology. Such an understanding is essential to planning and development if the effects of OCS activities are to be minimized.

LITERATURE CITED

Gates, C. E. 1979. Line transect and related issues. In R. M. Cormack, G. P. Patil, and D. S. Robson, eds. Sampling biological populations. Satellite Program in Statistical Biology, International Cooperative Publishing House, Fairfield, Md.

Irvine, A. Blair, J. E. Caffin, and H. I. Kochman. 1981. Aerial surveys for manatees and dolphins in western peninsular Florida with notes on sighting of sea turtles and crocodiles. U. S. Department of Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/50.

Leipper, D. F. 1954. Physical oceanography of the Gulf of Mexico. Pages 119-137 in P. S. Galtsoff, coord. Gulf of Mexico: its origin, waters, and marine life. U.S. Fish Wildl. Serv. Fish. Bull. 55(89).

Lynch, S. A. 1954. Geology of the Gulf of Mexico. Pages 67-86 in P. S. Galtsoff, coord. Gulf of Mexico: its origin, waters, and marine life. U.S. Fish Wildl. Serv. Fish. Bull. 55(89).

Marmer, H. A. 1954. Tides and sea level in the Gulf of Mexico. Pages 101-118 in P. S. Galtsoff, coord. Gulf of Mexico: its origin, waters, and marine life. U.S. Fish Wildl. Serv. Fish. Bull. 55(89).

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences, 2nd ed. McGraw-Hill, New York. 675 pp.

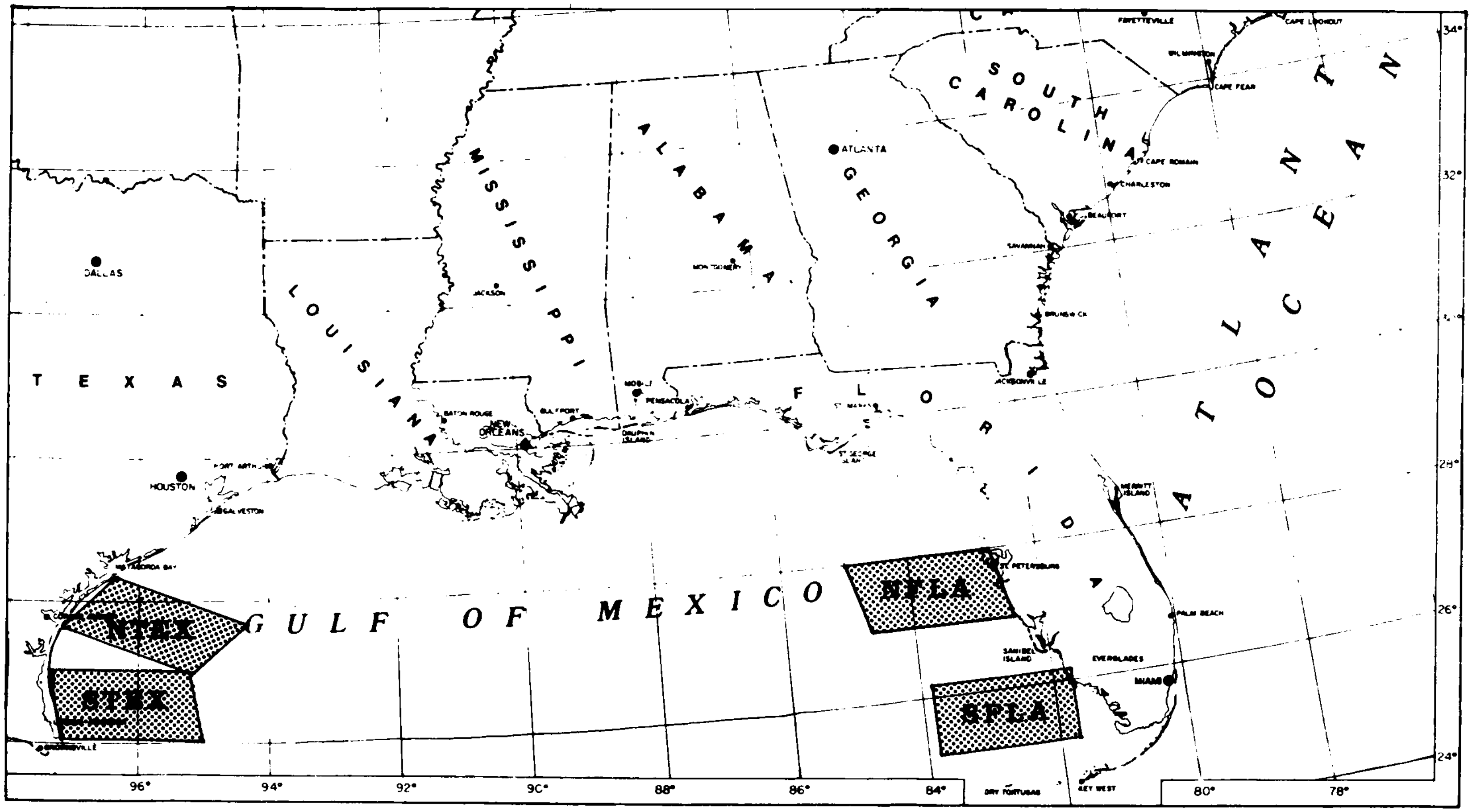
Schmidly, D. J. 1981. Marine mammals of the Southeastern United States coast and the Gulf of Mexico. U. S. Department of the Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/41.

Schmidly, D. J., and S. H. Shane. 1978. A biological assessment of the cetacean fauna of the Texas coast. National Technical Information Service, Springfield, Va. PB-281763. 38 pp.

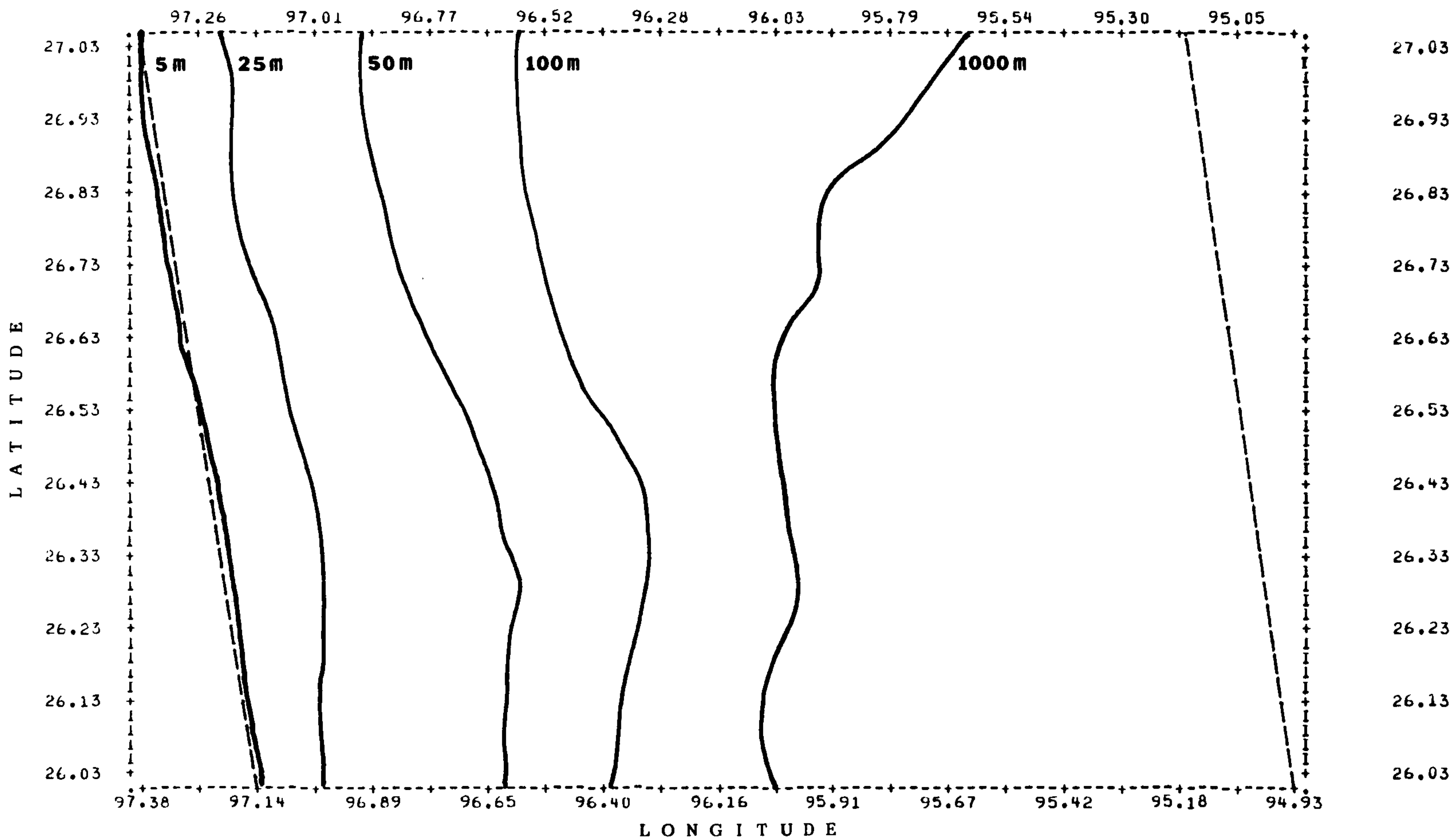
Sturges, W., and J. P. Blaha. 1976. A western boundary current in the Gulf of Mexico. Science 192:367-369.

APPENDIX: MAPS

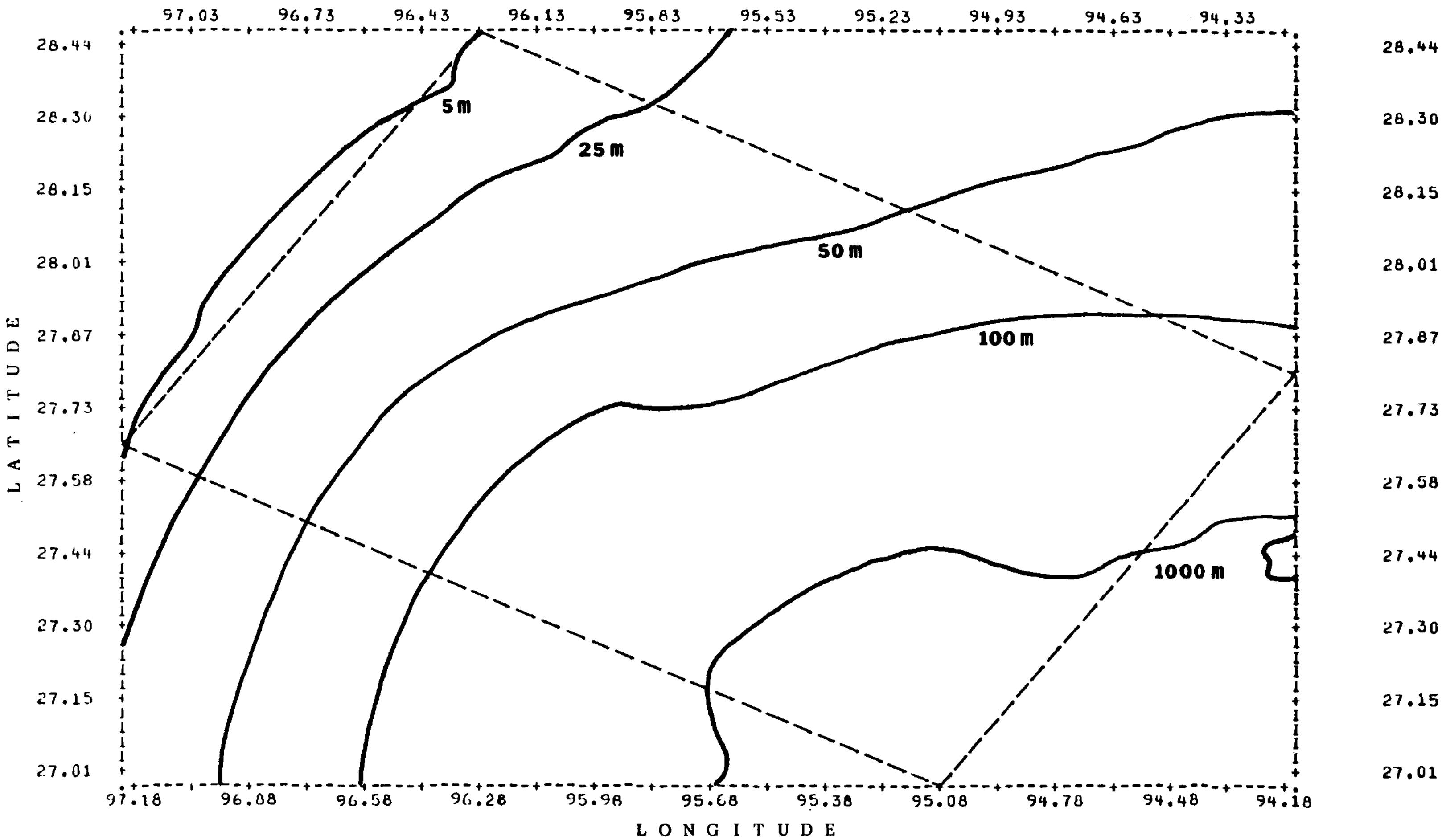
APPENDIX: MAPS Concluded



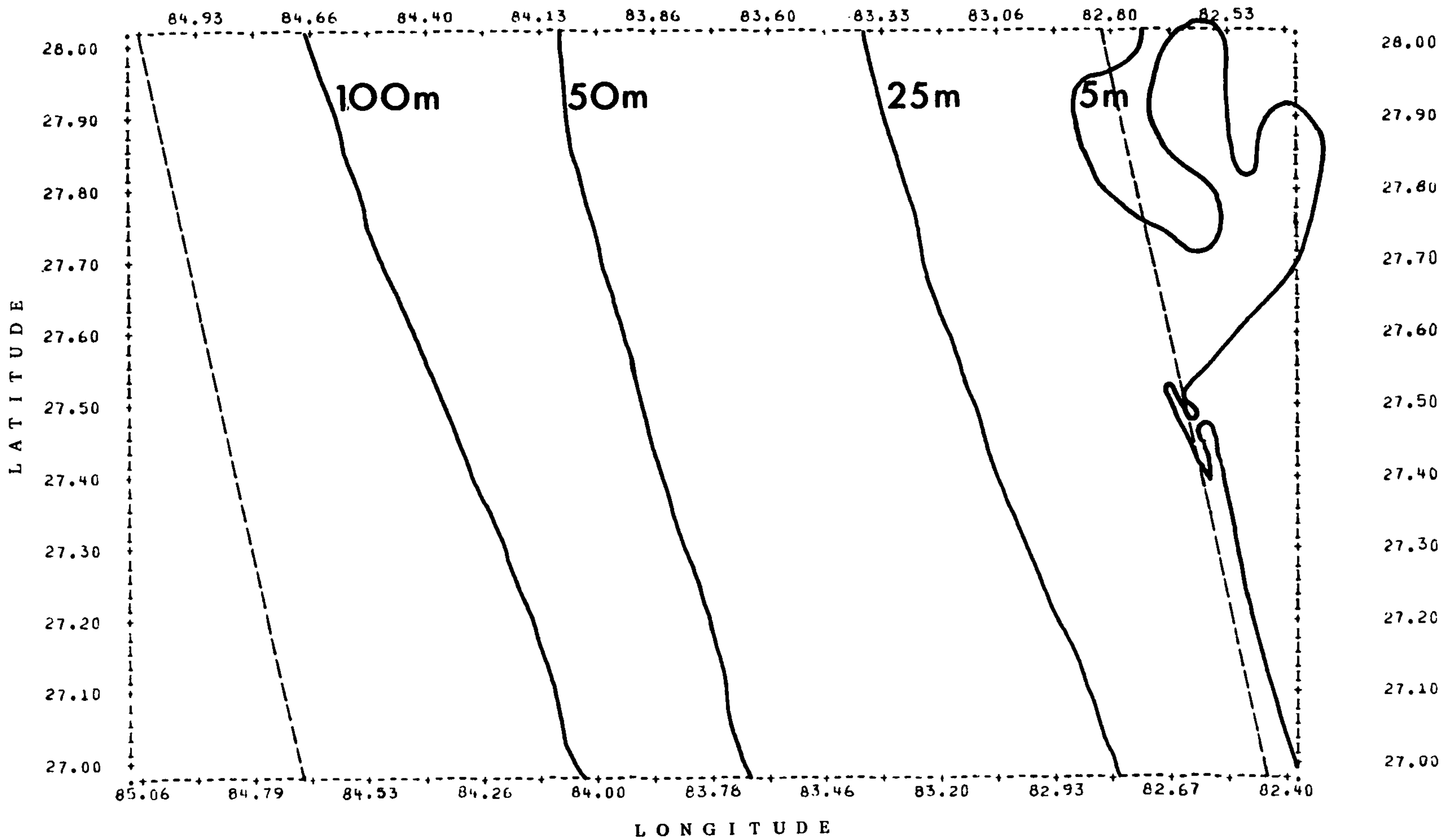
Map 1. Survey subunits sampled in the Pilot Study of marine mammals, birds, and turtles.



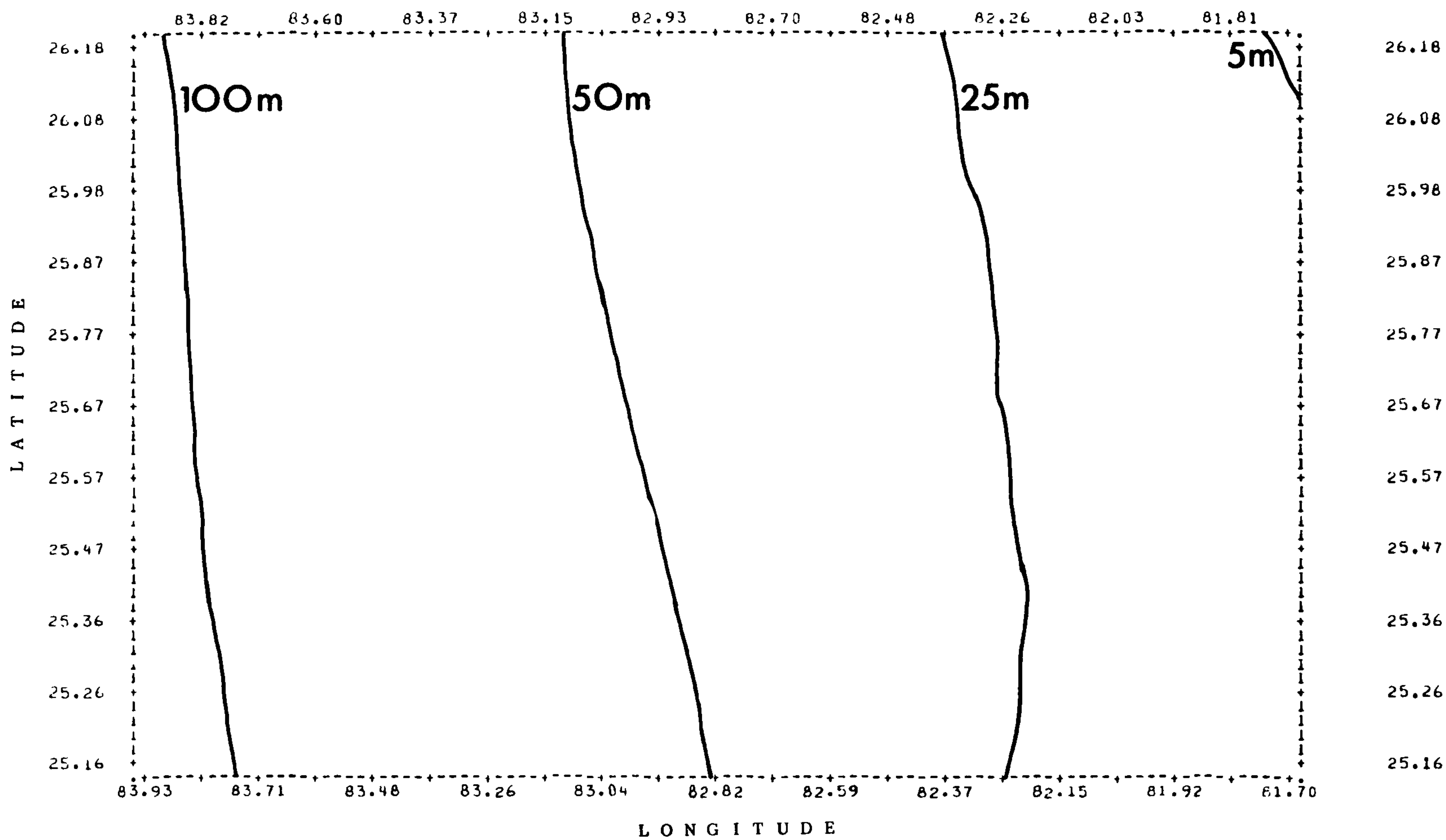
Map 2. Diagrammatic map of STEX survey subunit with bathymetric contours (solid lines). Eastern and western limits of survey subunit are shown as broken lines.



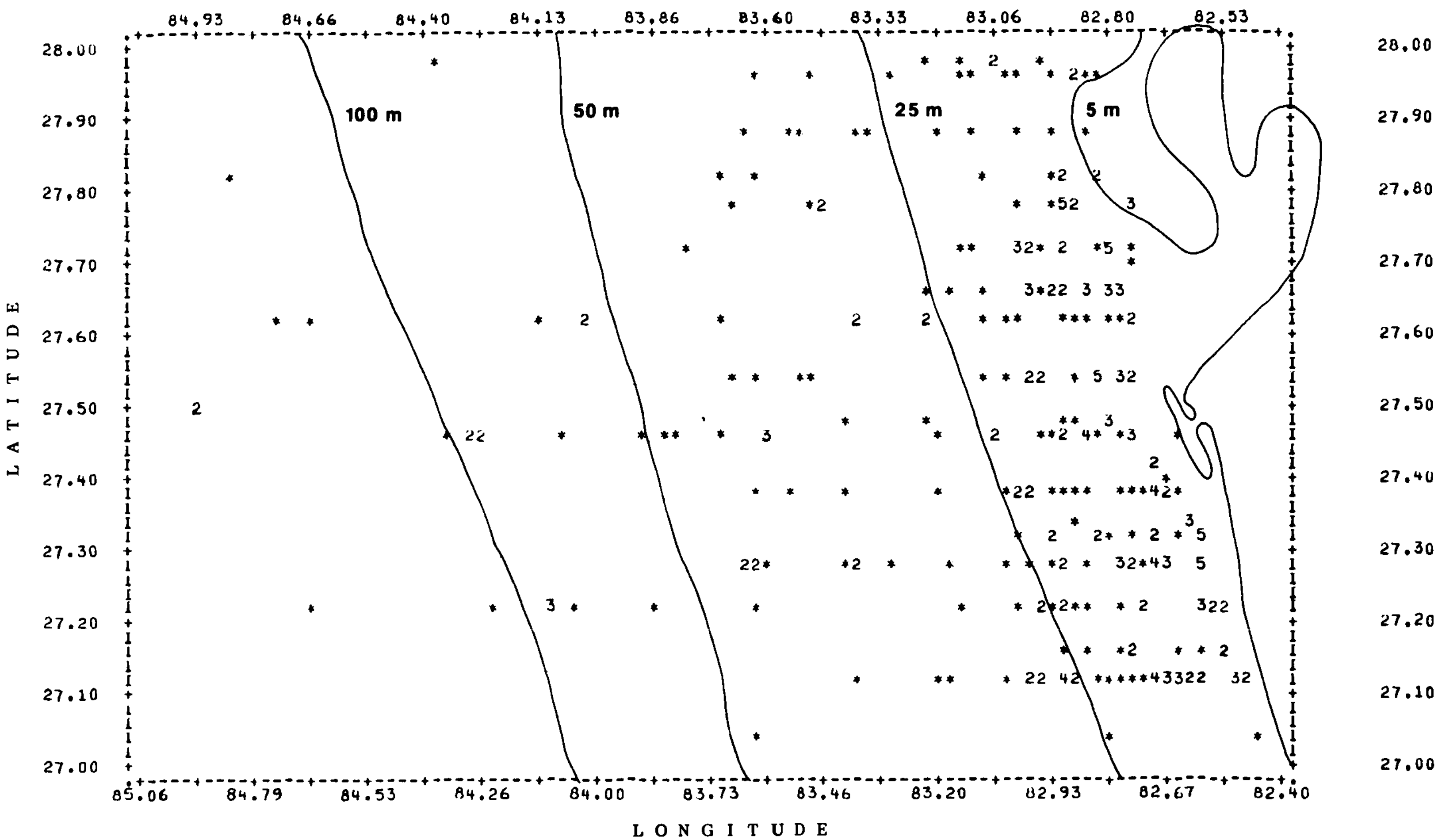
Map 3. Diagrammatic map of NTEX survey subunit with bathymetric contours (solid lines). Subunit boundaries are shown as broken lines.



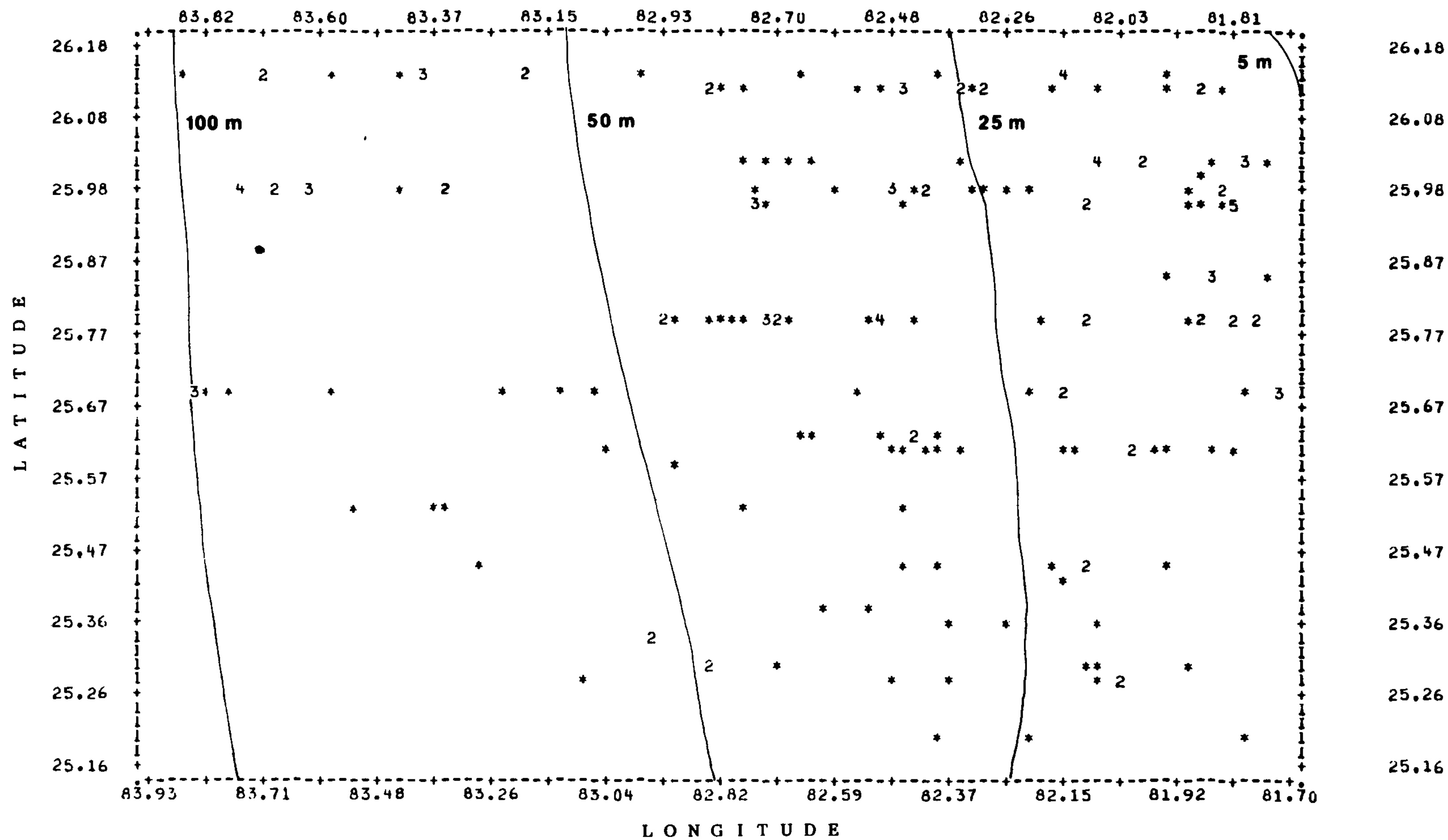
Map 4. Diagrammatic map of NFLA survey subunit with bathymetric contours (solid lines). Eastern and western limits of survey subunit are shown as broken lines.



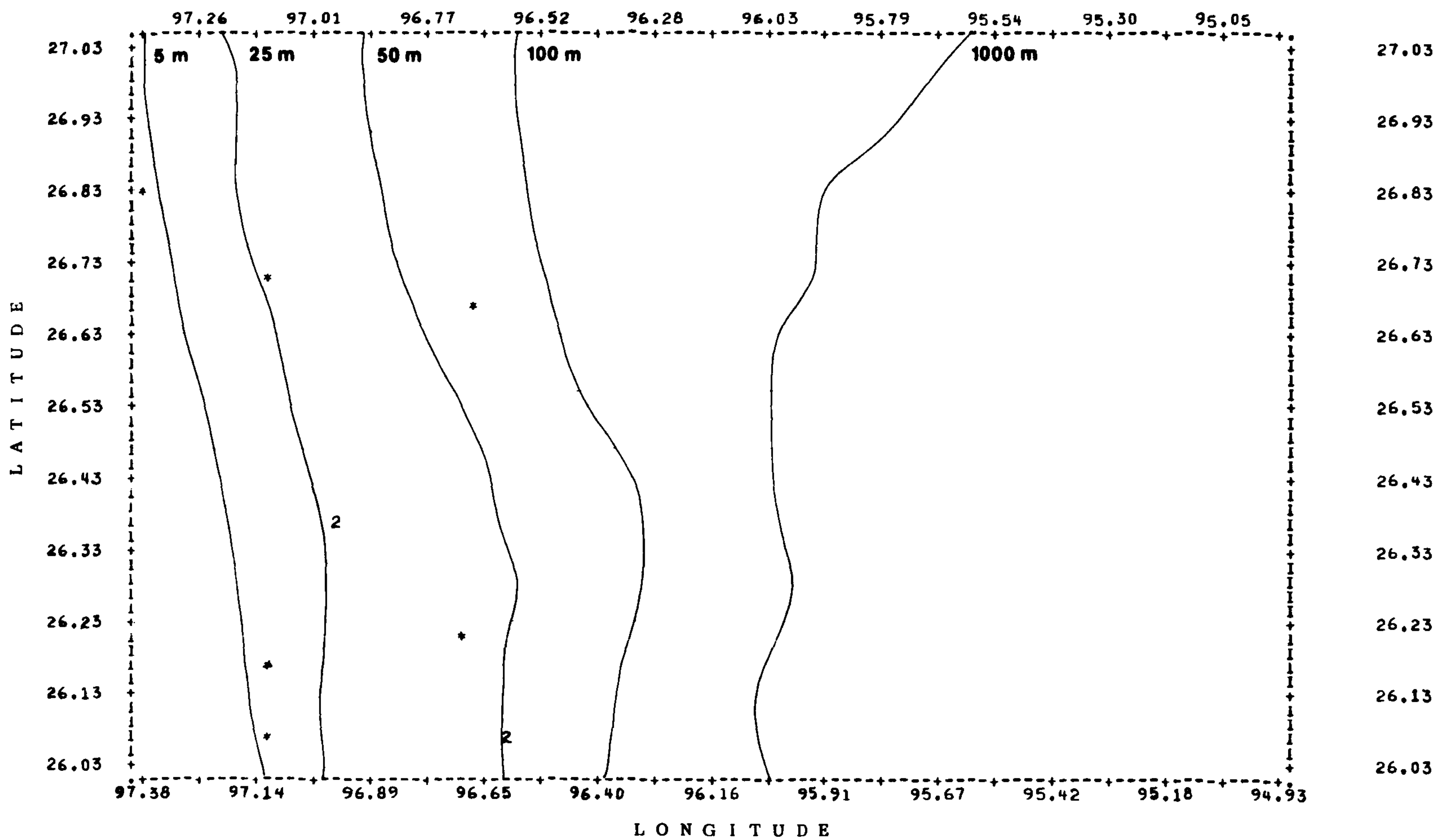
Map 5. Diagrammatic map of SFLA survey subunit with bathymetric contours (solid lines). Limits of map are survey subunit boundaries.



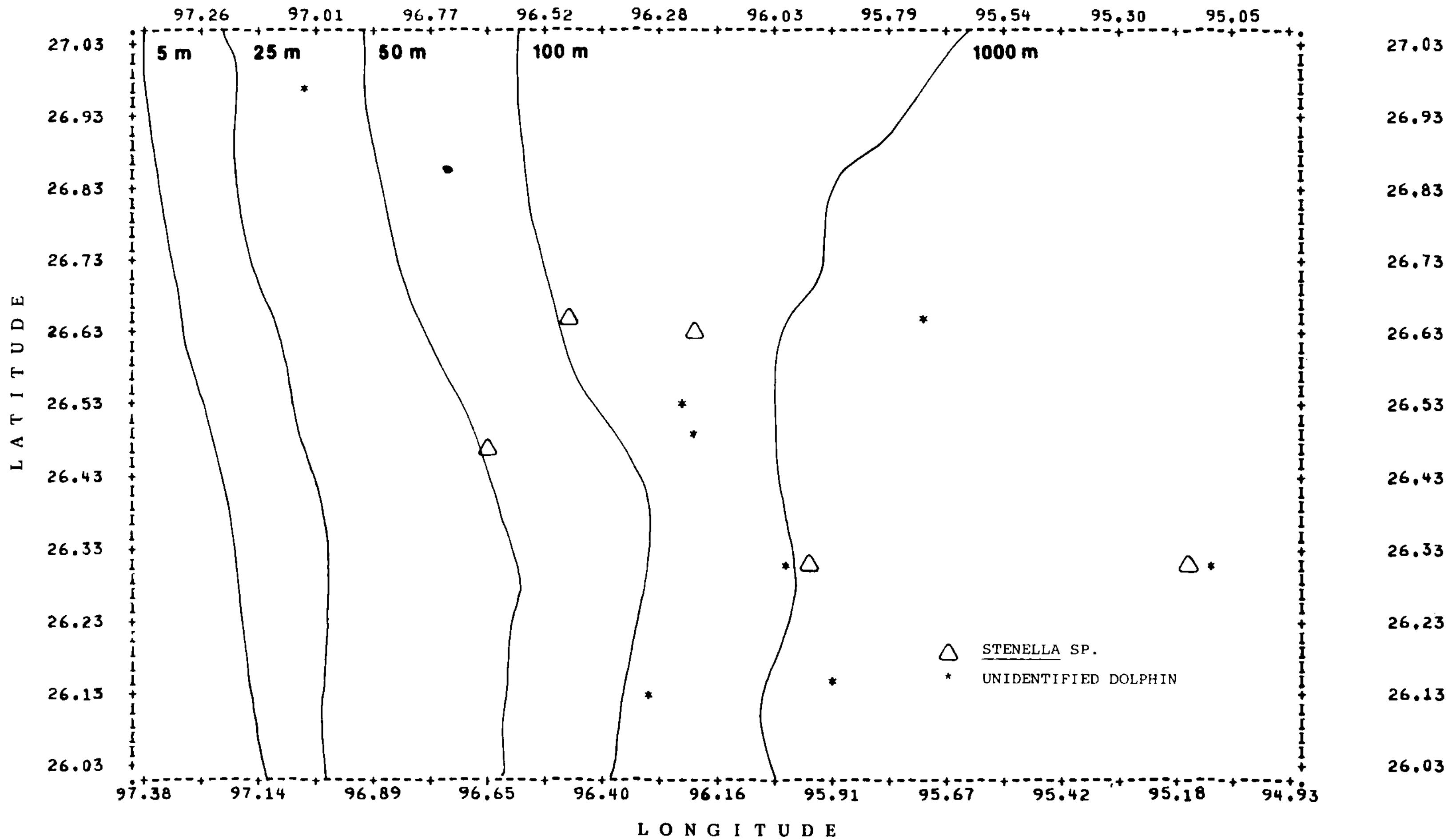
Map 6. Sightings of mammals, birds, and turtles in NFLA during August. Numbers indicate the number of sightings at a single map point.



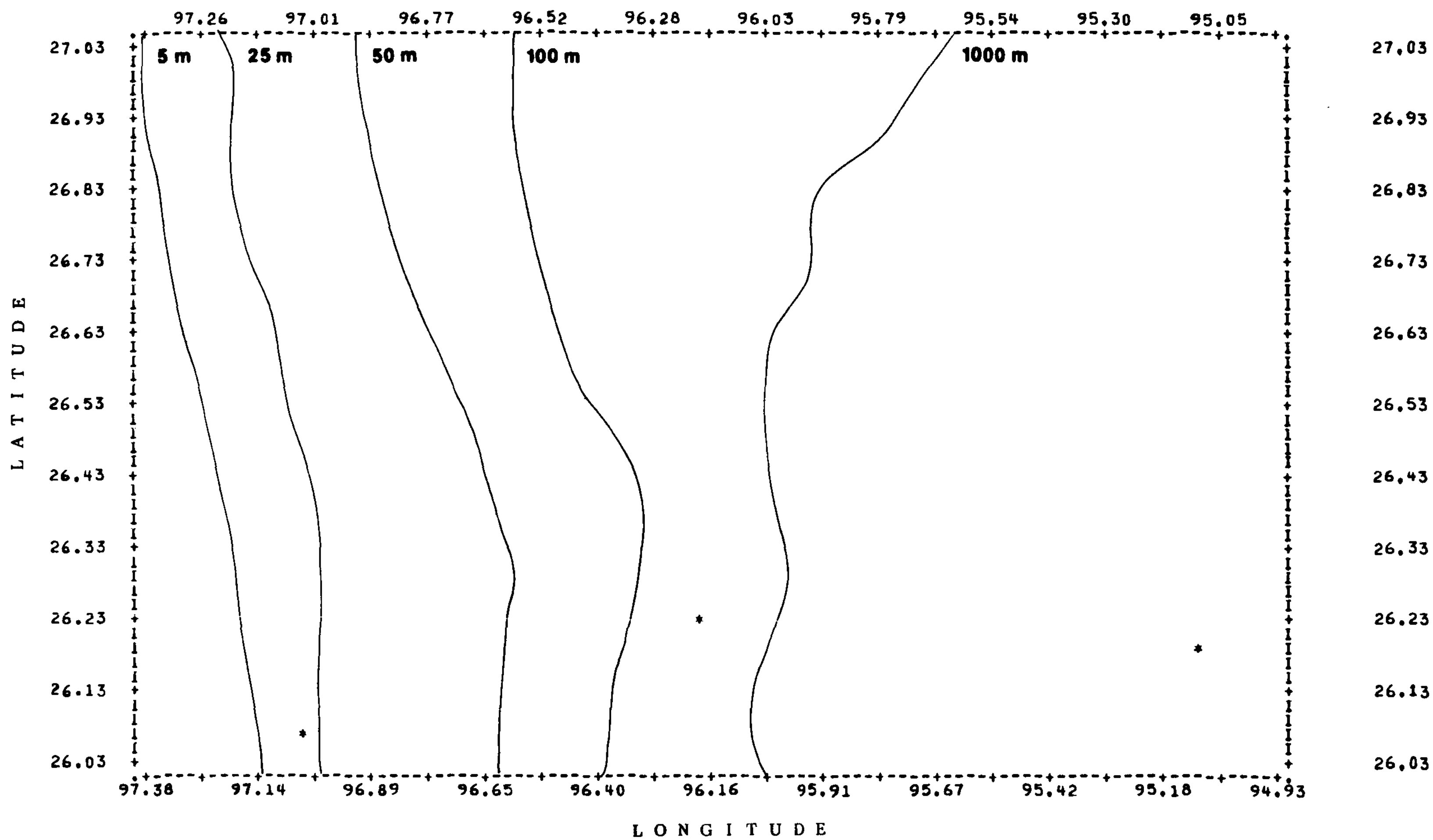
Map 7. Sightings of mammals, birds, and turtles in SFLA during August. Numbers indicate the number of sightings at a single map point.



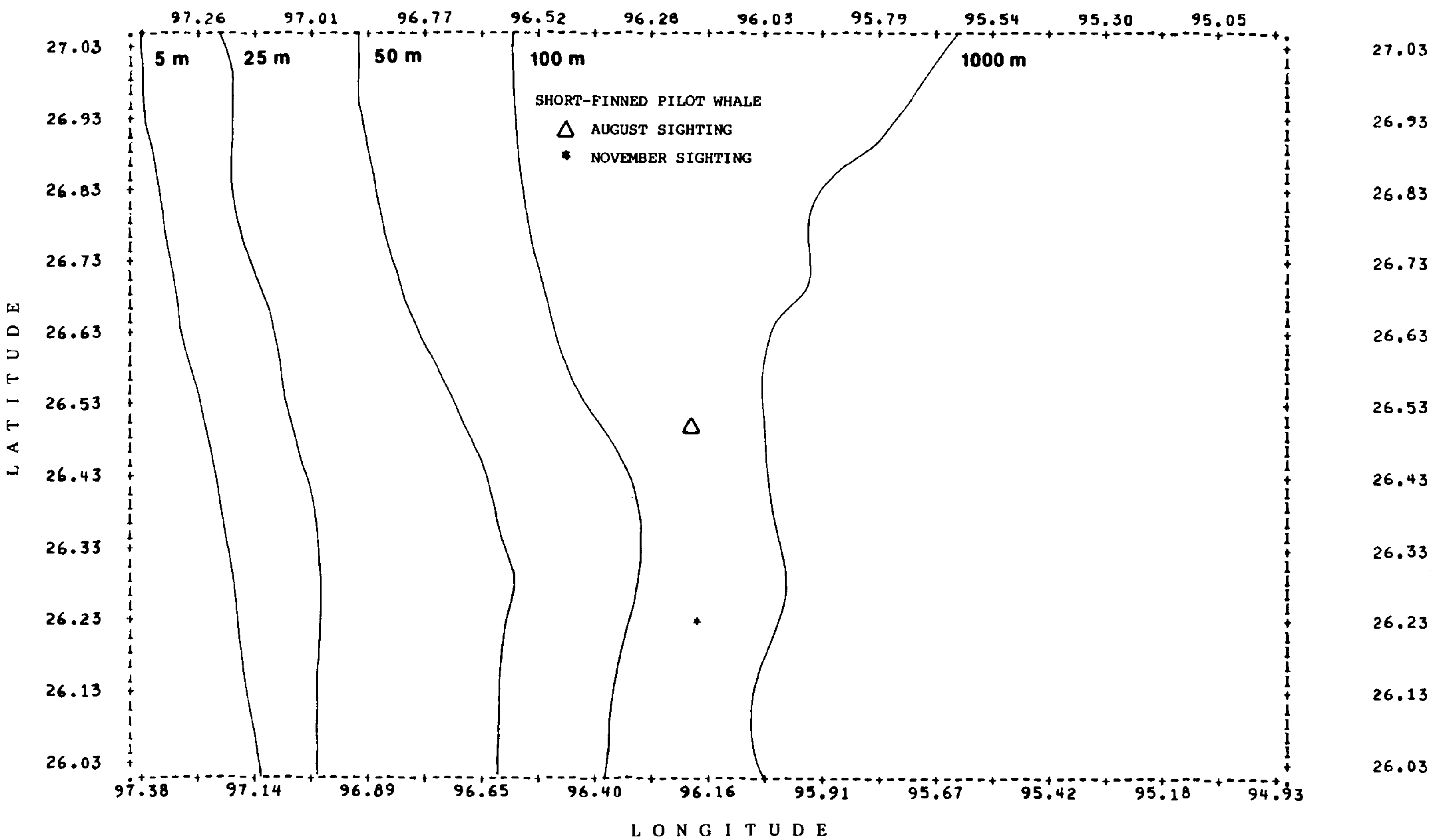
Map 8. Groups of bottlenose dolphins sighted in STEX during November. Numbers indicate the number of sightings at a single map point.



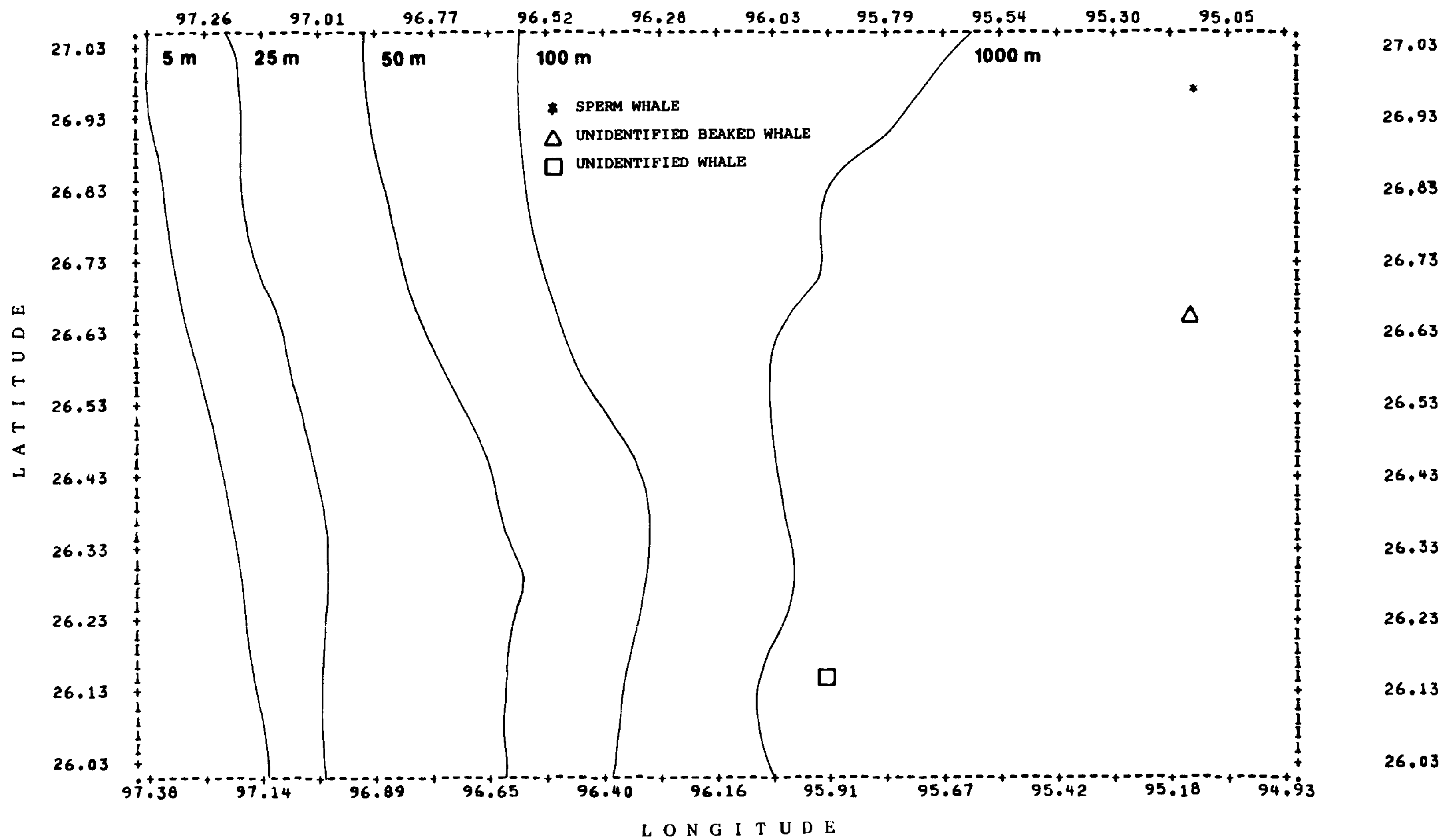
Map 9. Groups of Stenella sp. and unidentified dolphins sighted in STEX during August.



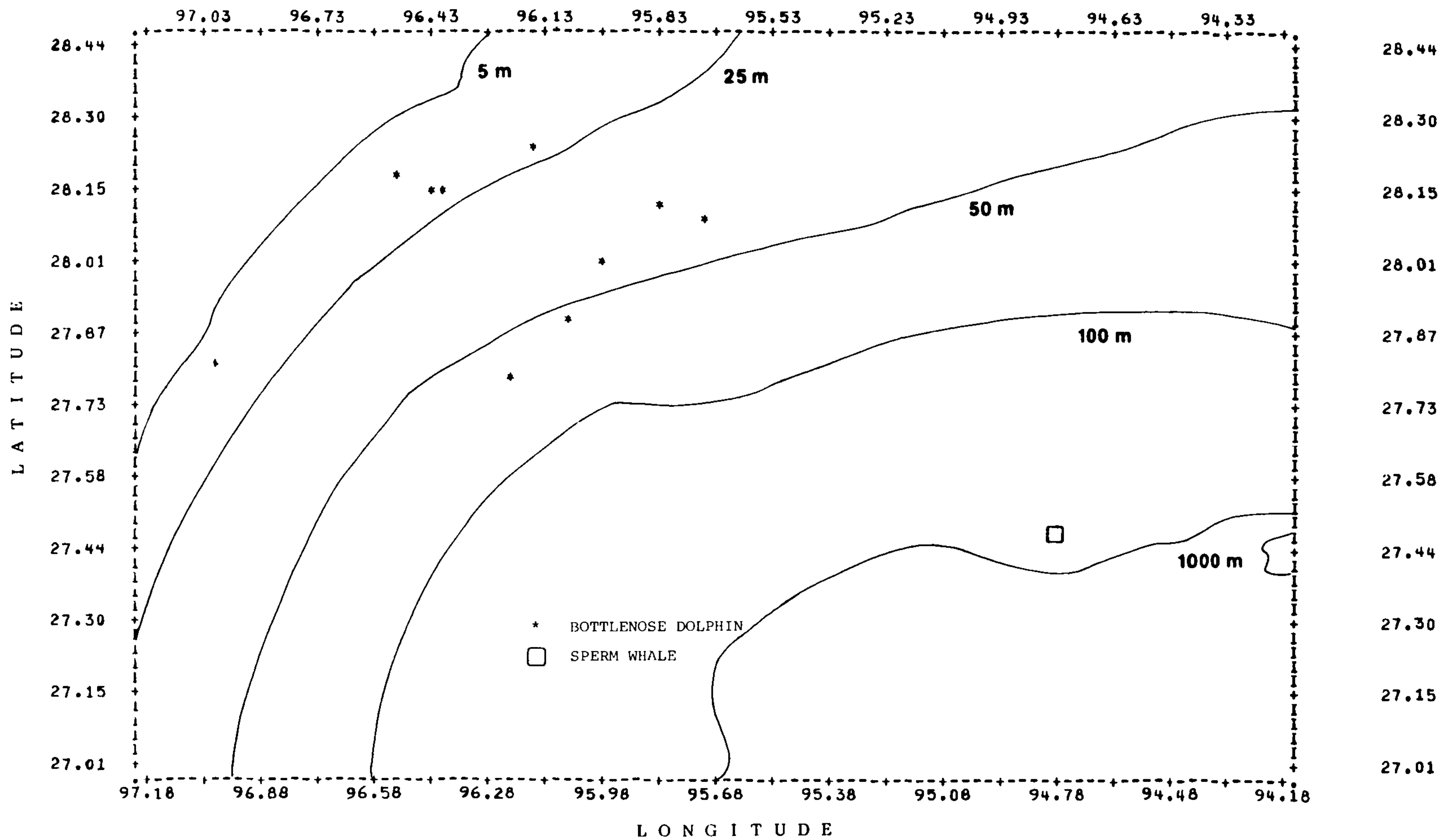
Map 10. Groups of unidentified dolphins sighted in STEX during November.



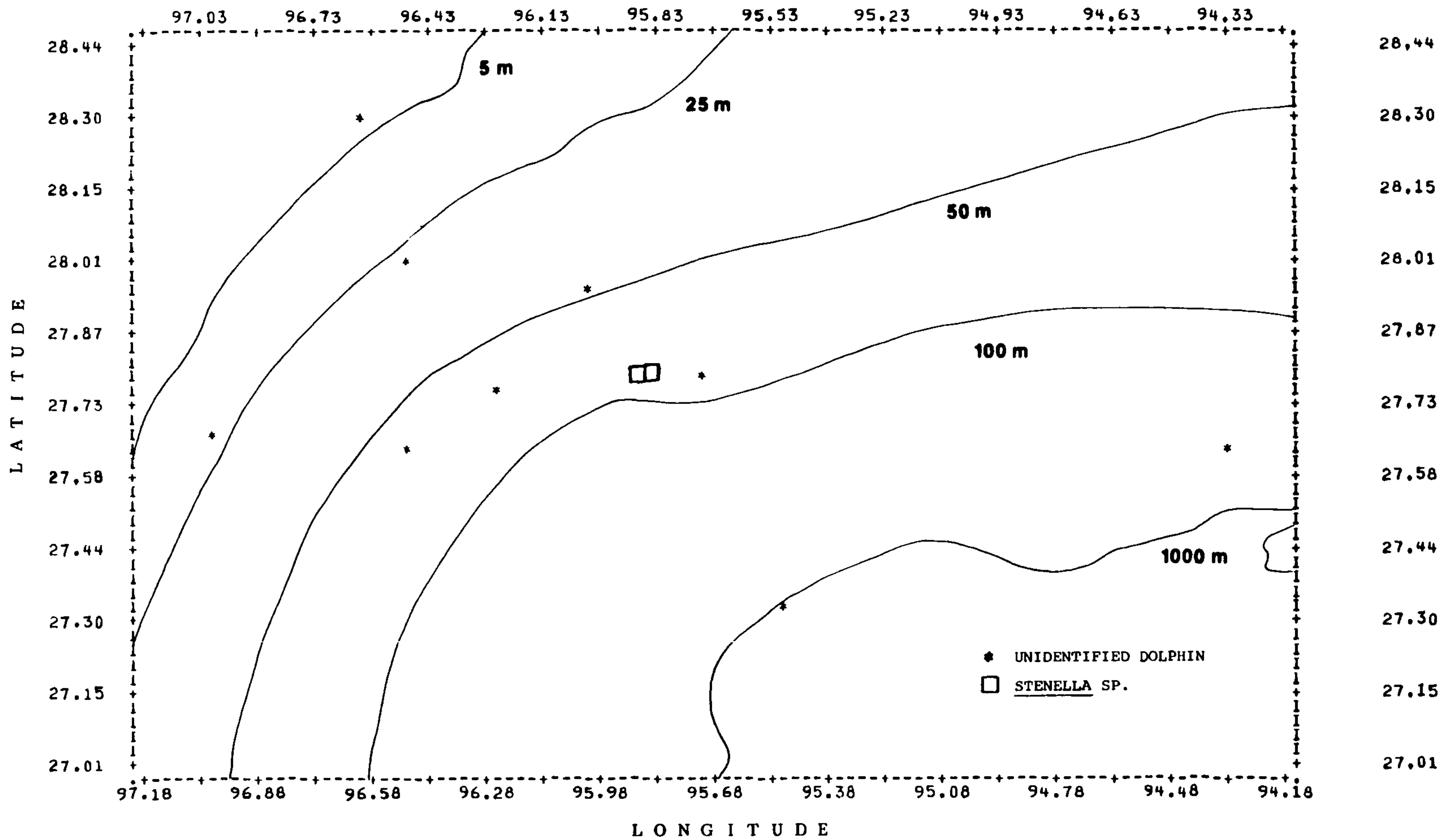
Map 11. Short-finned pilot whales seen in STEX during the Pilot Study.



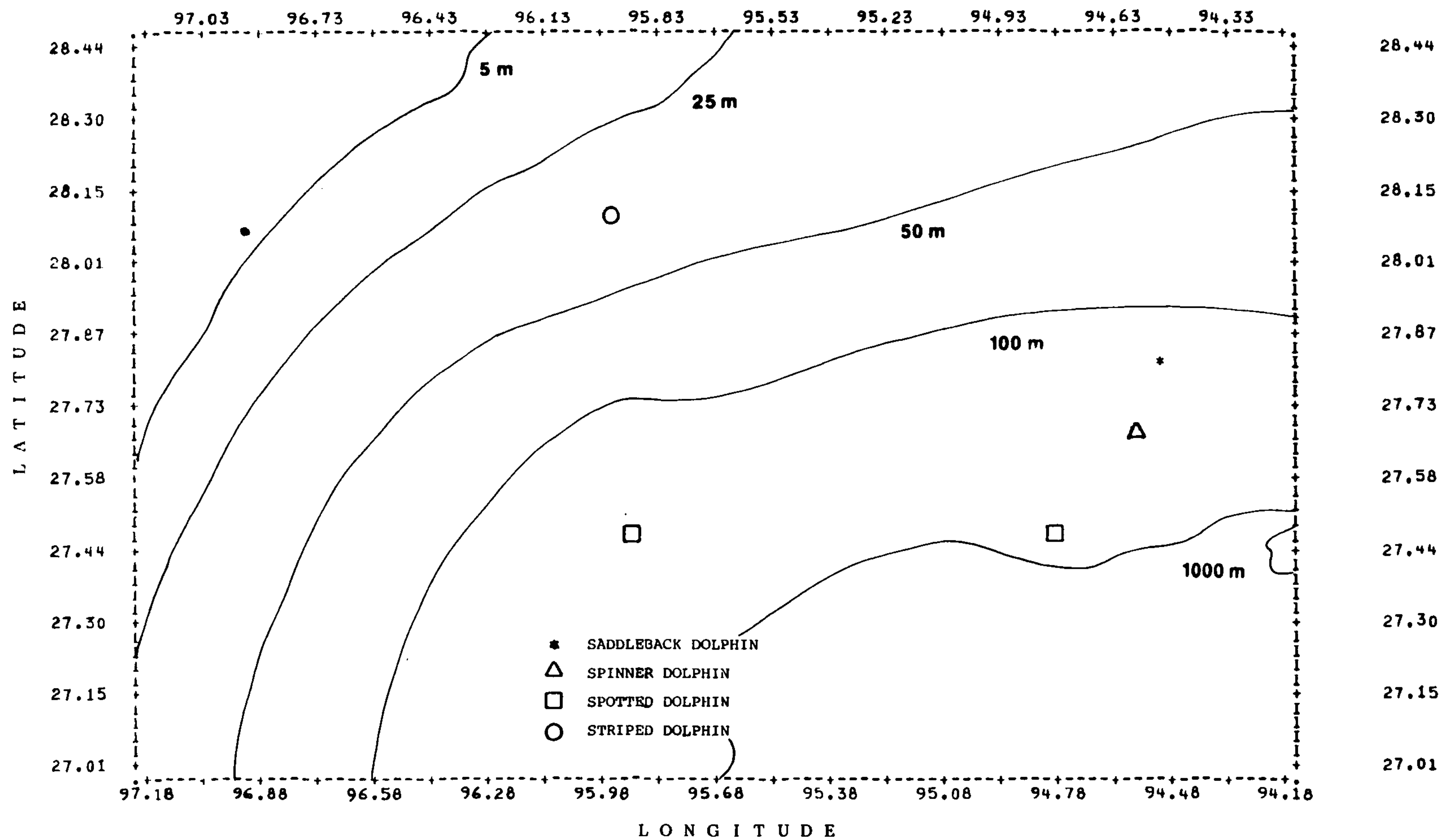
Map 12. Groups of sperm whales, unidentified beaked whales, and unidentified whales sighted in STEX during August.



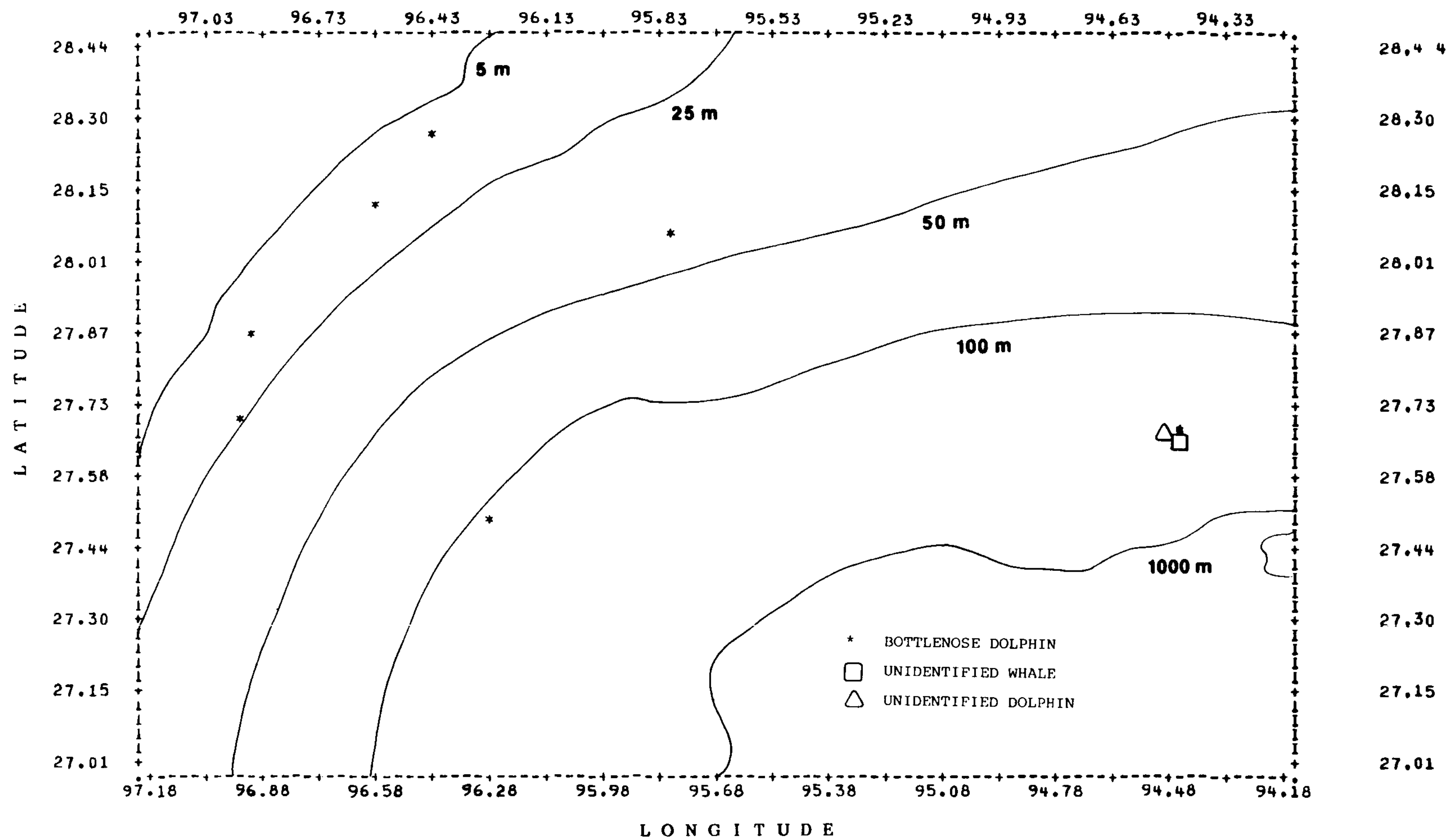
Map 13. Groups of bottlenose dolphins and sperm whales sighted in NTEX during August.



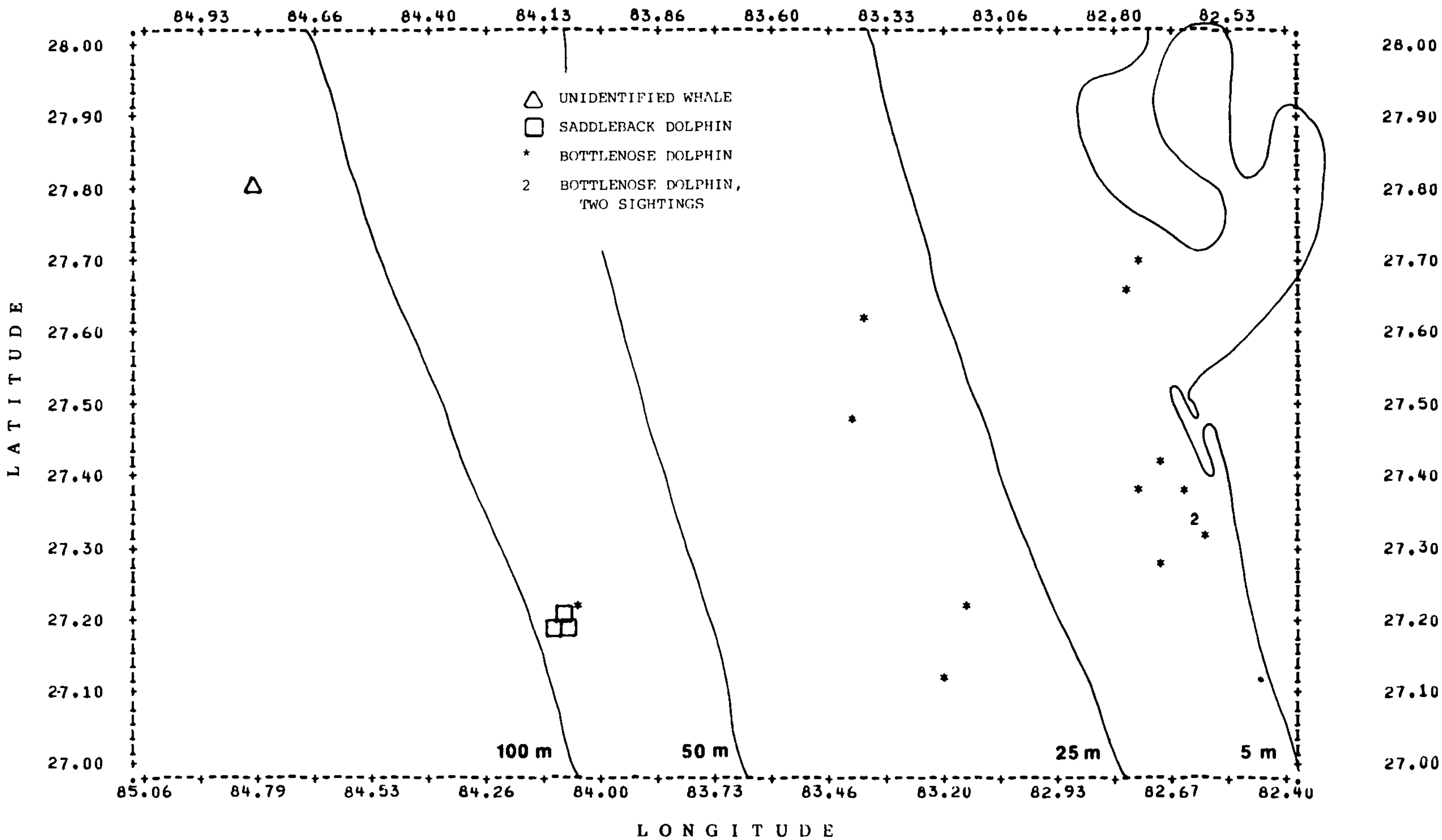
Map 14. Groups of unidentified dolphins and Stenella sp. sighted in NTEX during August.



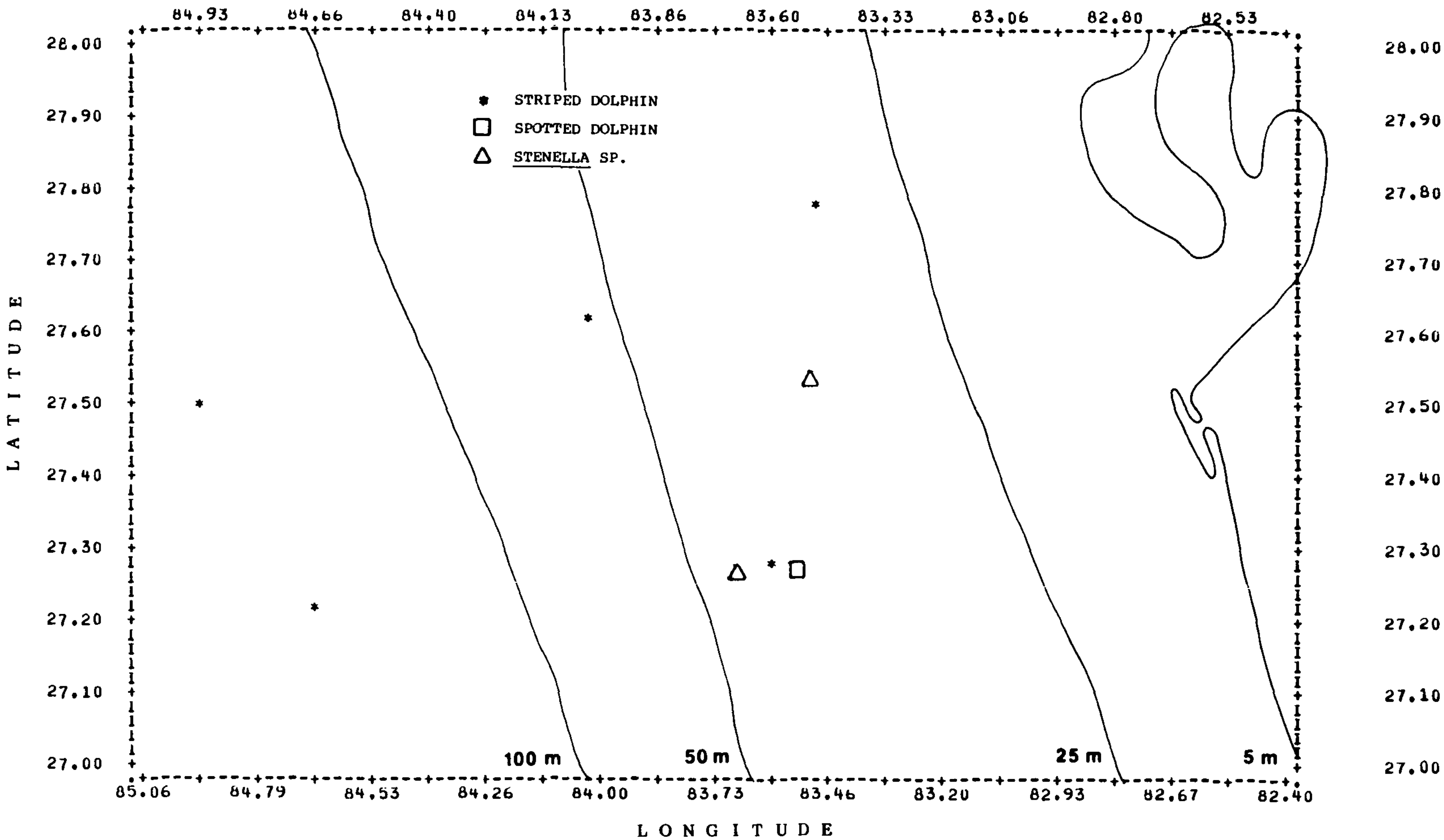
Map 15. Groups of saddleback, spinner, spotted, and striped dolphins sighted in NTEX during August.



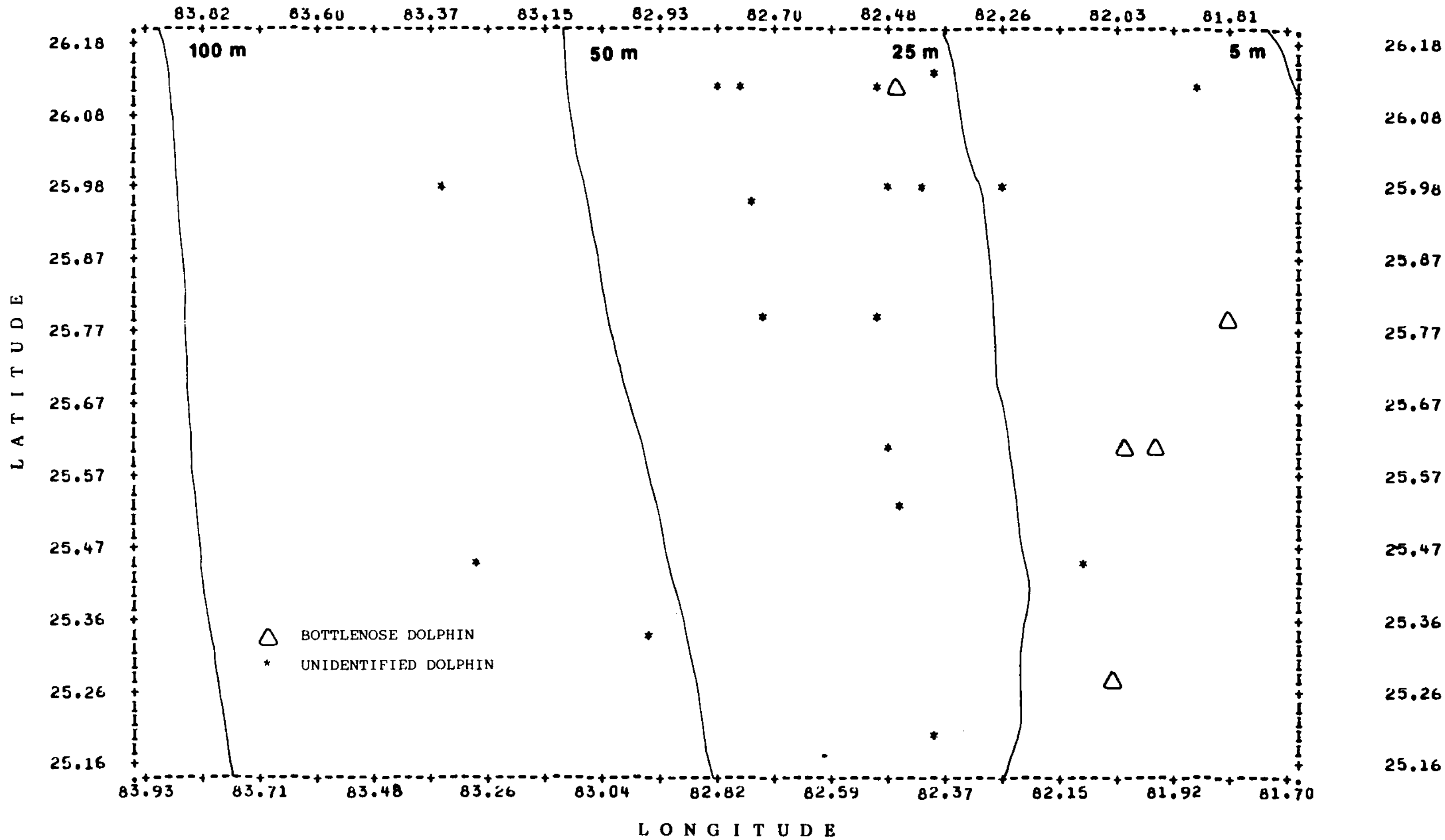
Map 16. Groups of bottlenose dolphins, unidentified whales, and unidentified dolphins sighted in NTEX during November.



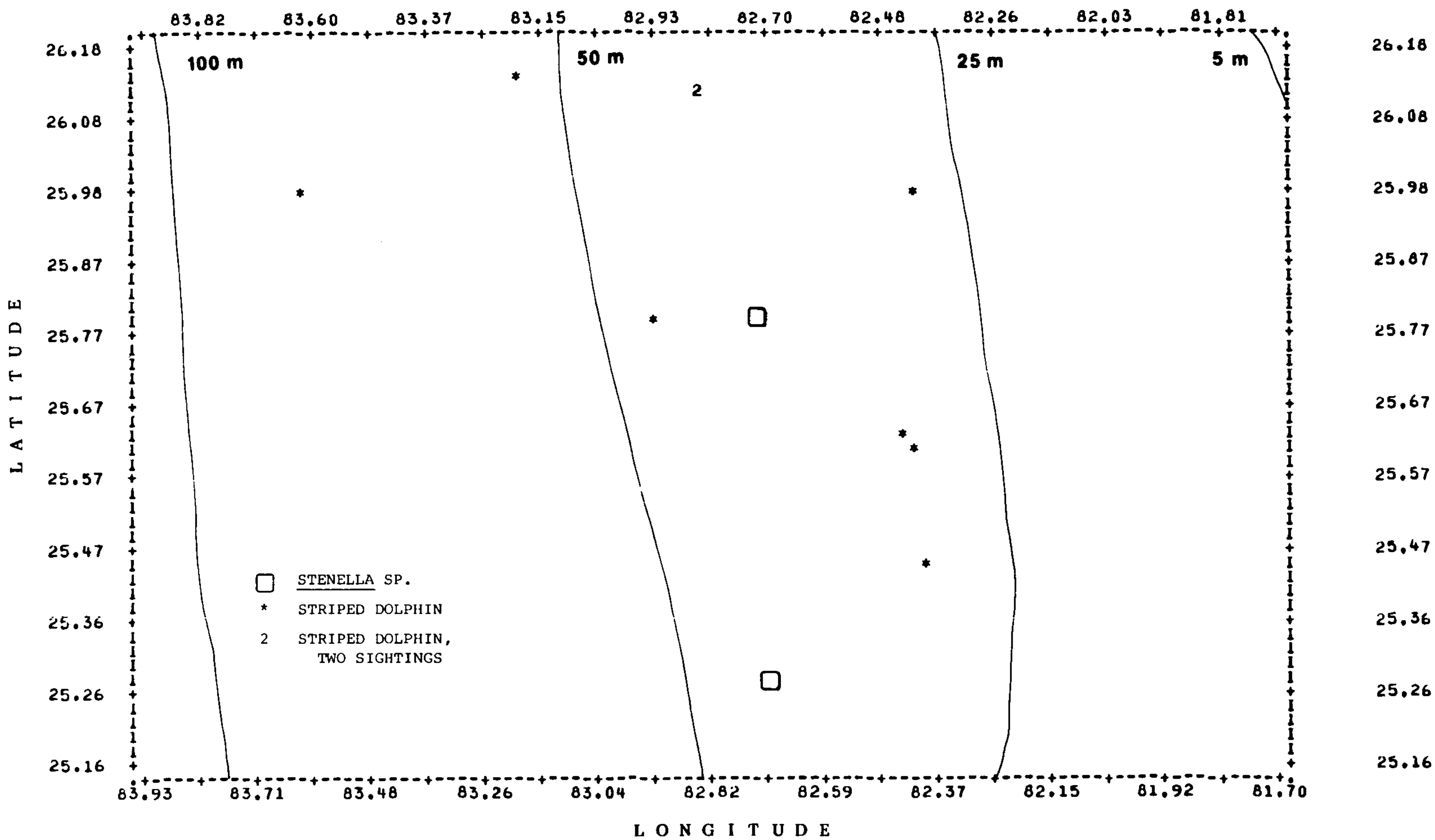
Map 17. Groups of unidentified whales, saddleback dolphins, and bottlenose dolphins sighted in NFLA during August.



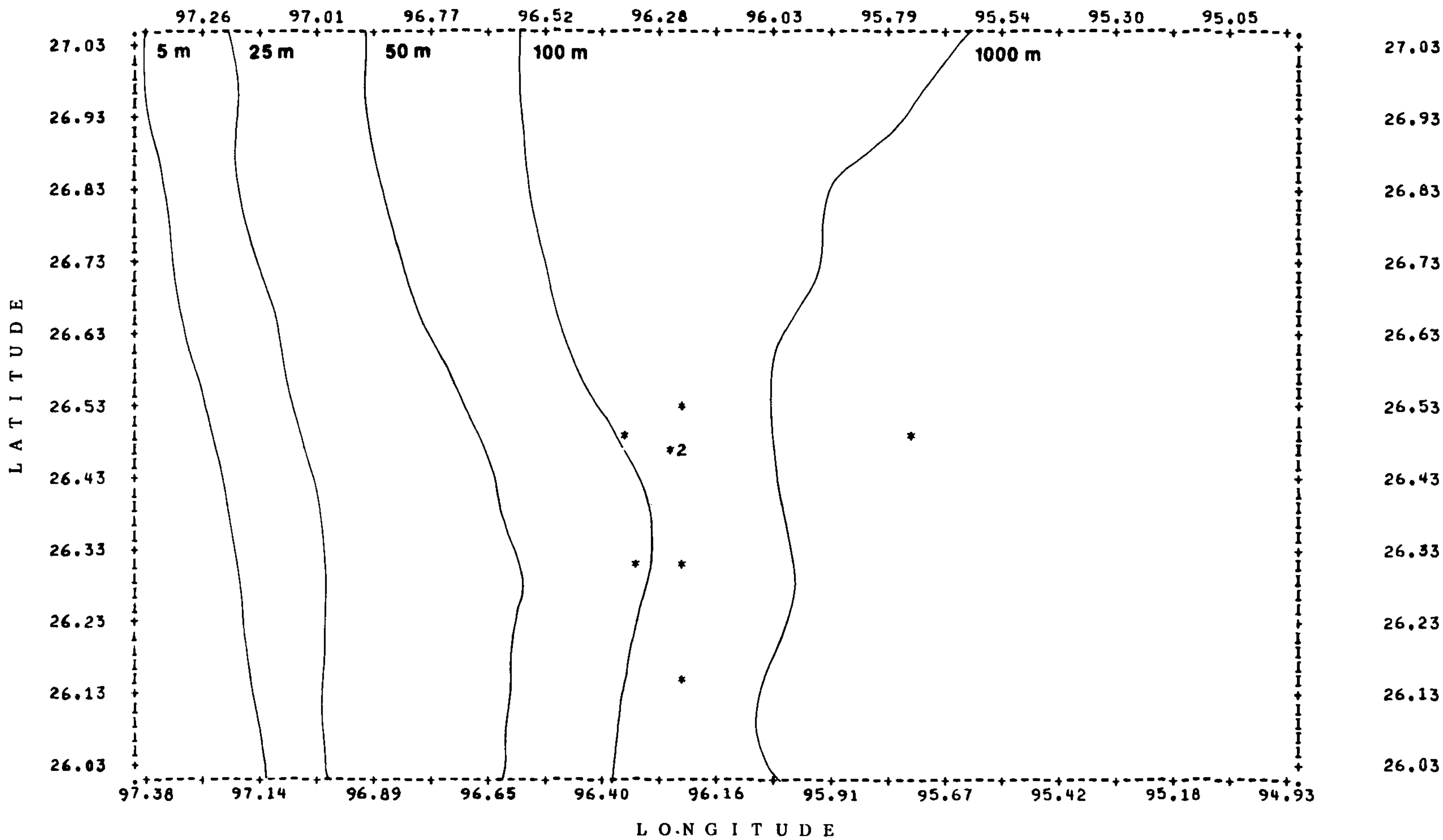
Map 18. Groups of striped dolphins, spotted dolphins, and Stenella sp. sighted in NFLA during August.



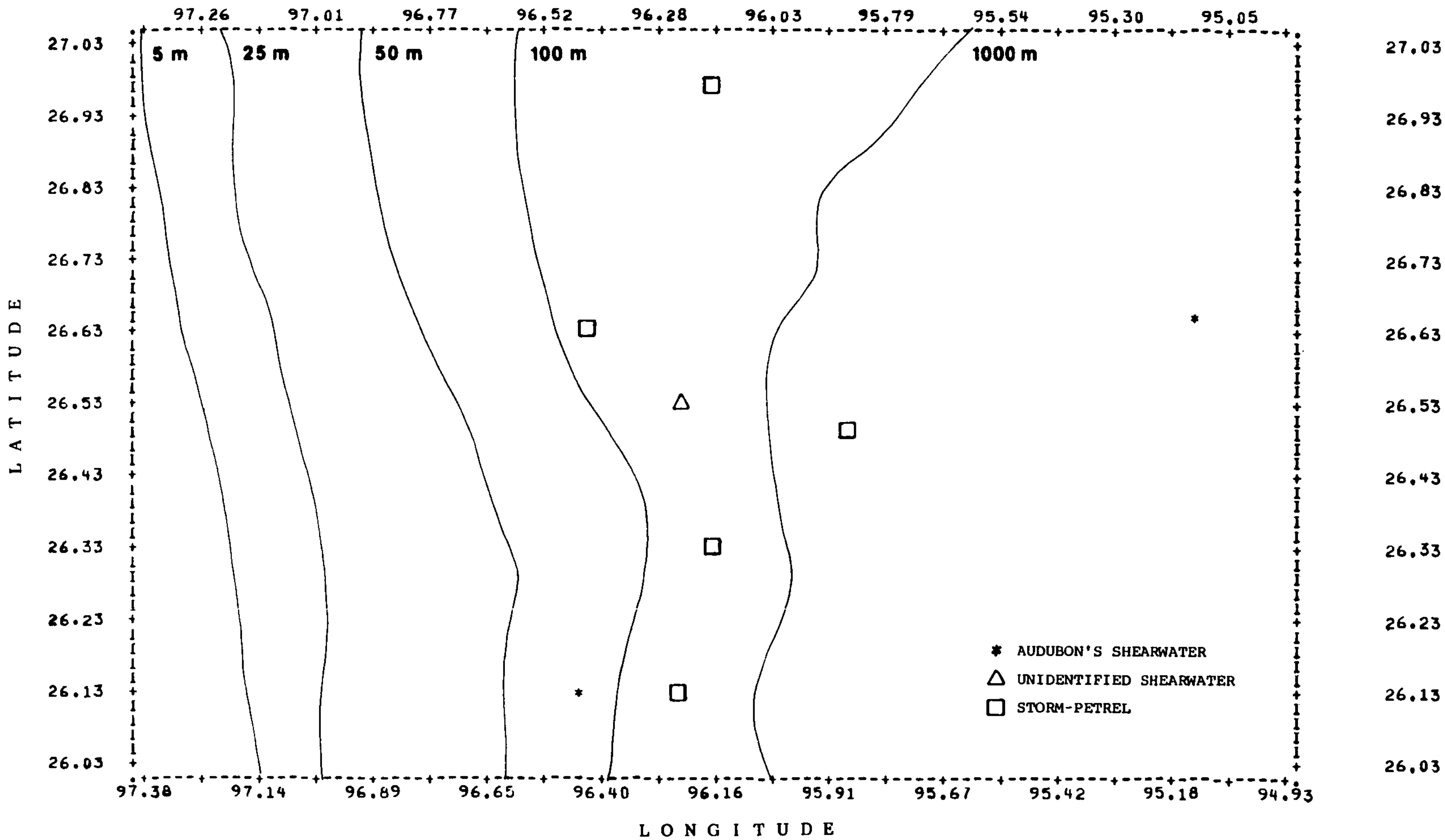
Map 19. Groups of bottlenose dolphins and unidentified dolphins sighted in SFLA during August.



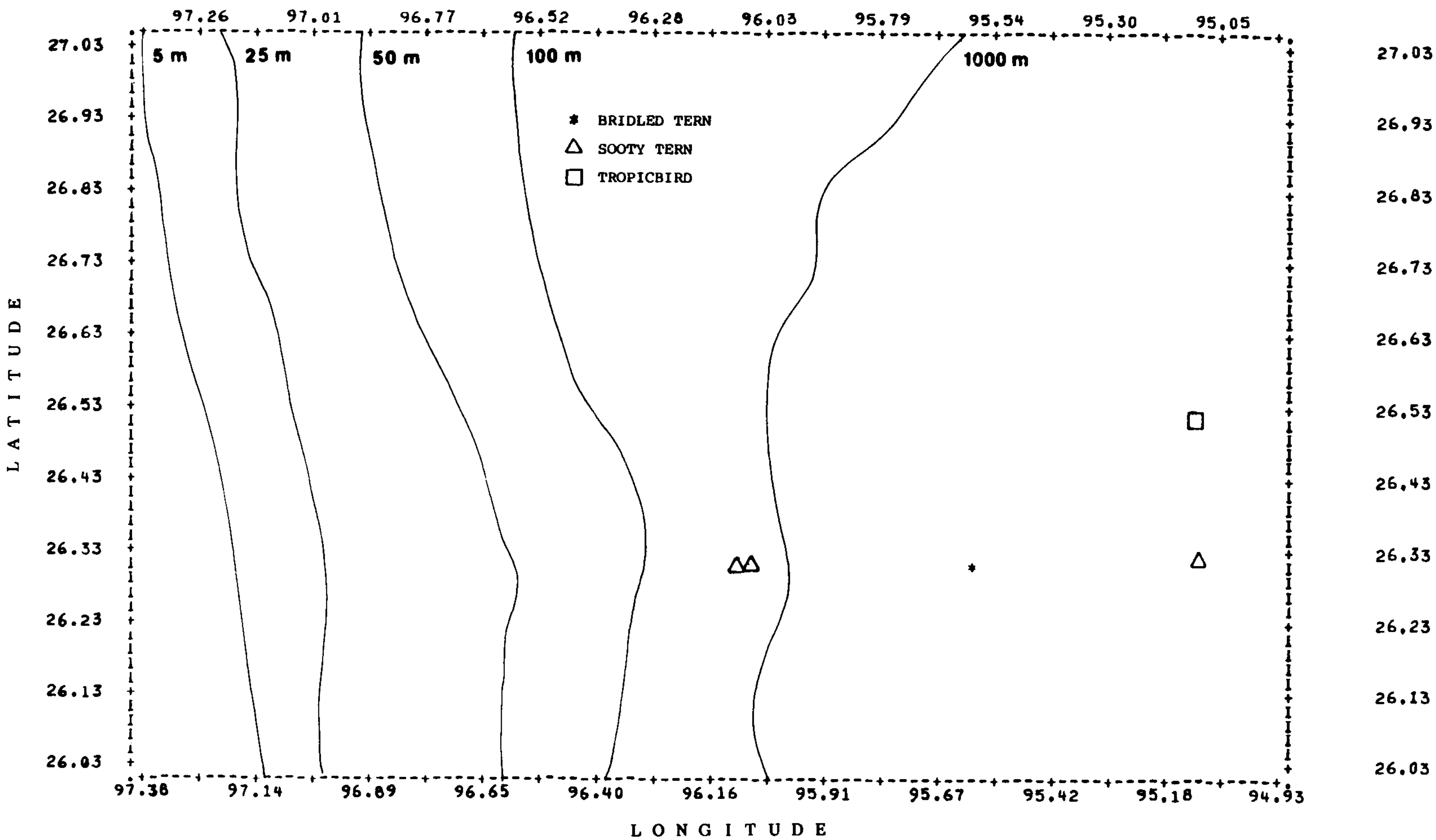
Map 20. Groups of Stenella sp. and striped dolphins sighted in SFLA during August.



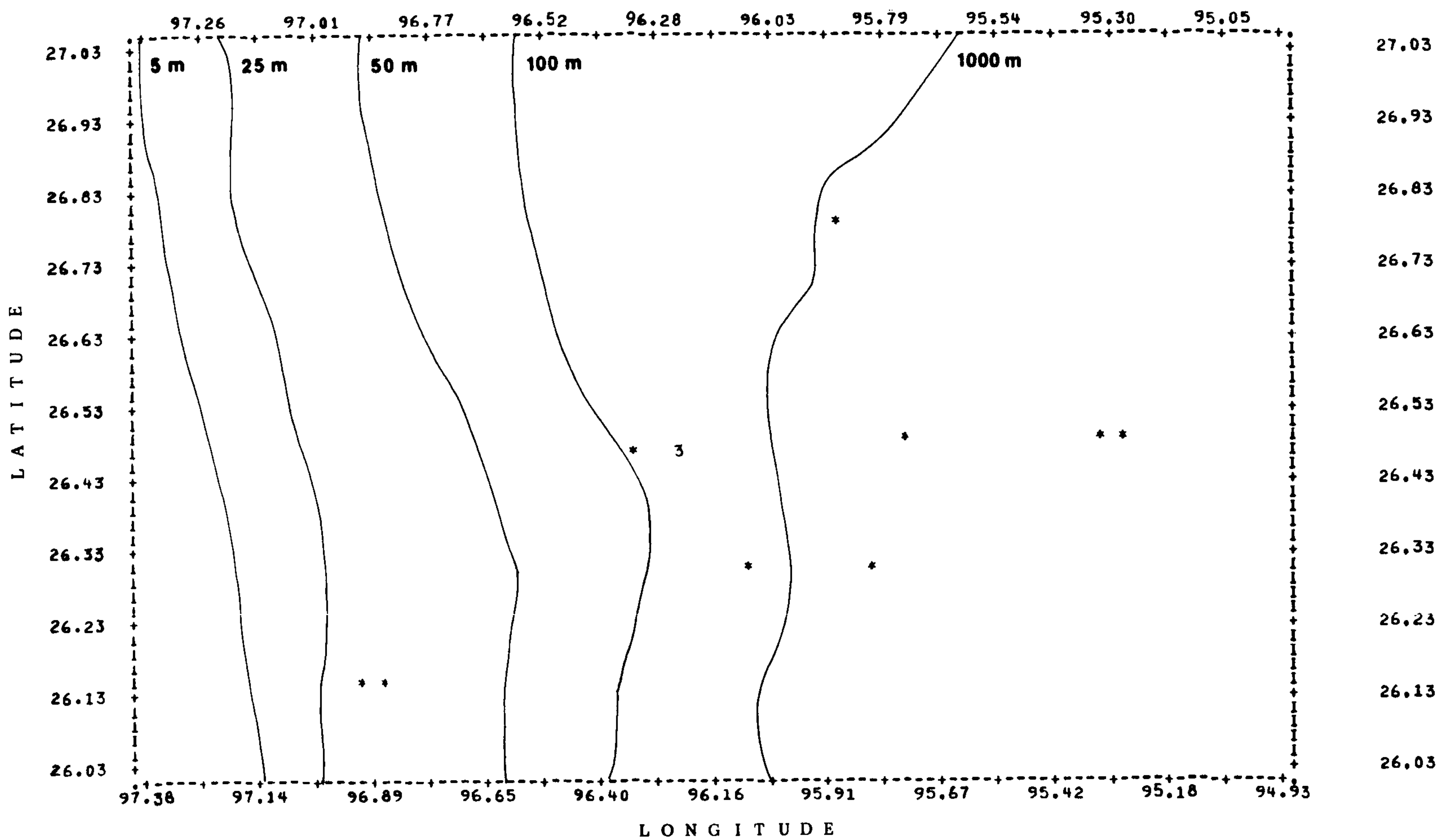
Map 21. Groups of Cory's shearwaters sighted in STEX during August. Numbers indicate the number of sightings at a single map point.



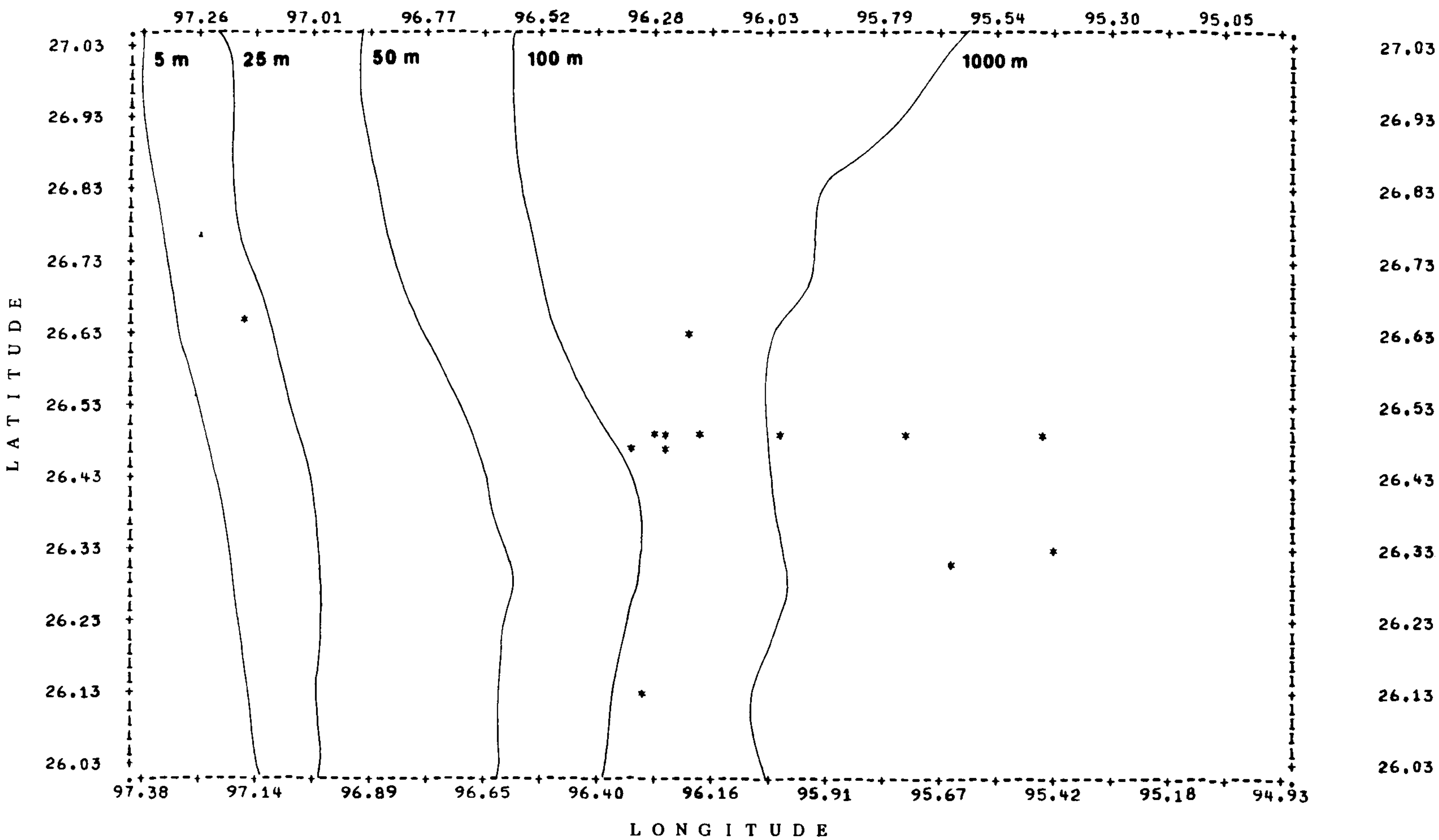
Map 22. Groups of Audubon's shearwaters, unidentified shearwaters, and storm-petrels sighted in STEX during August.



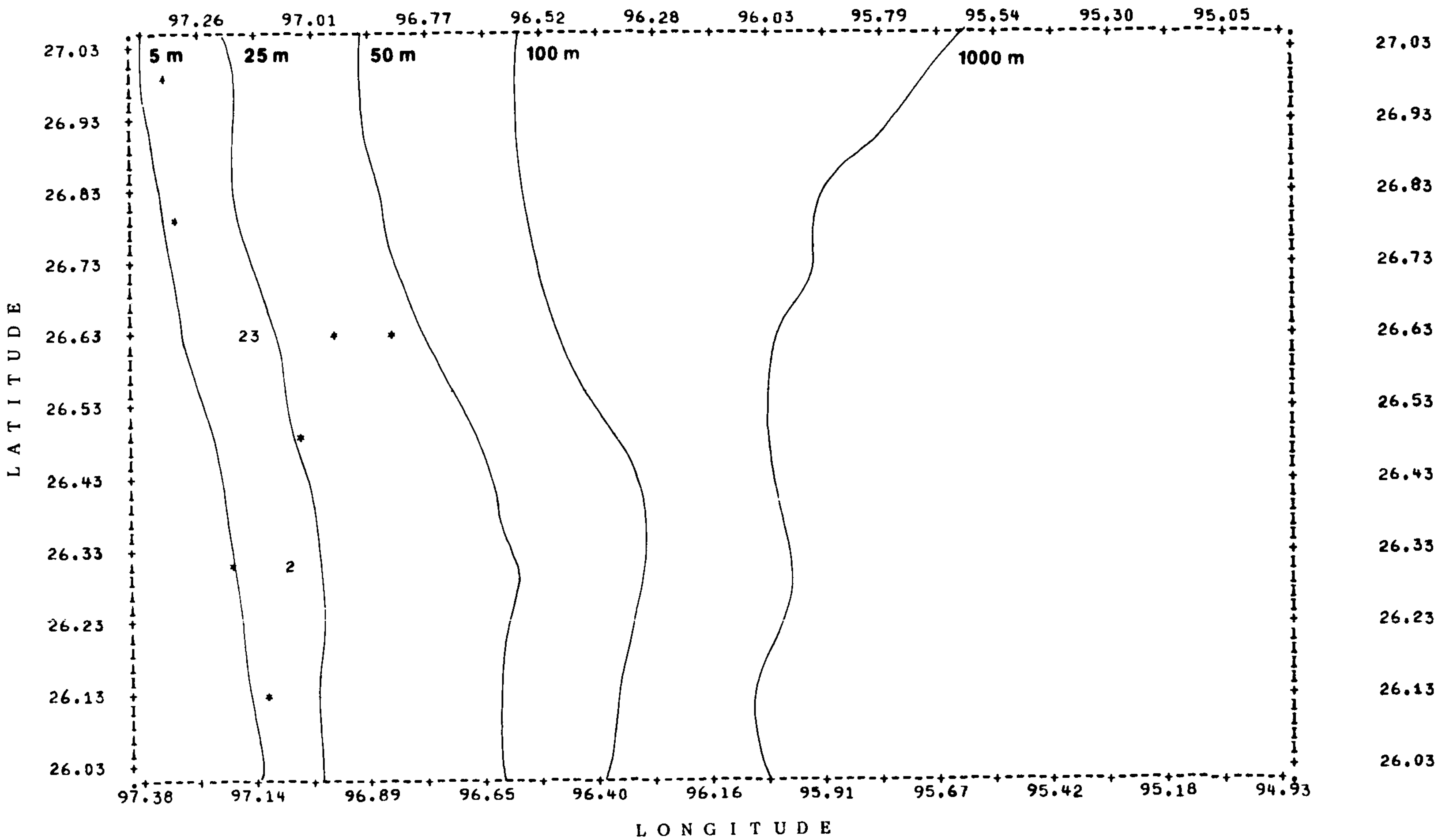
Map 23. Groups of bridled terns, sooty terns, and tropicbirds sighted in STEX during August.



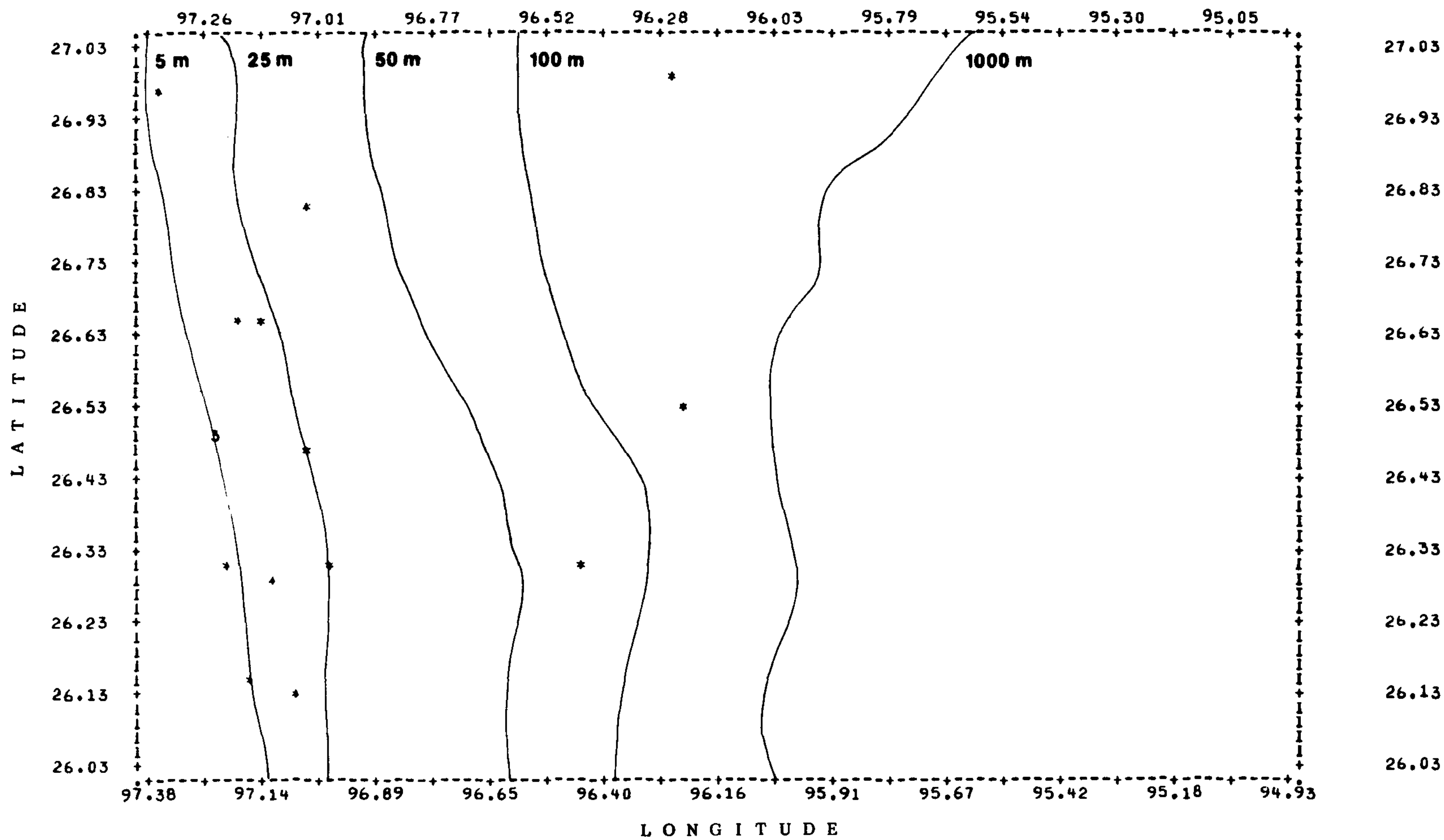
Map 24. Groups of black terns sighted in STEX during August. Numbers indicate the number of sightings at a single map point.



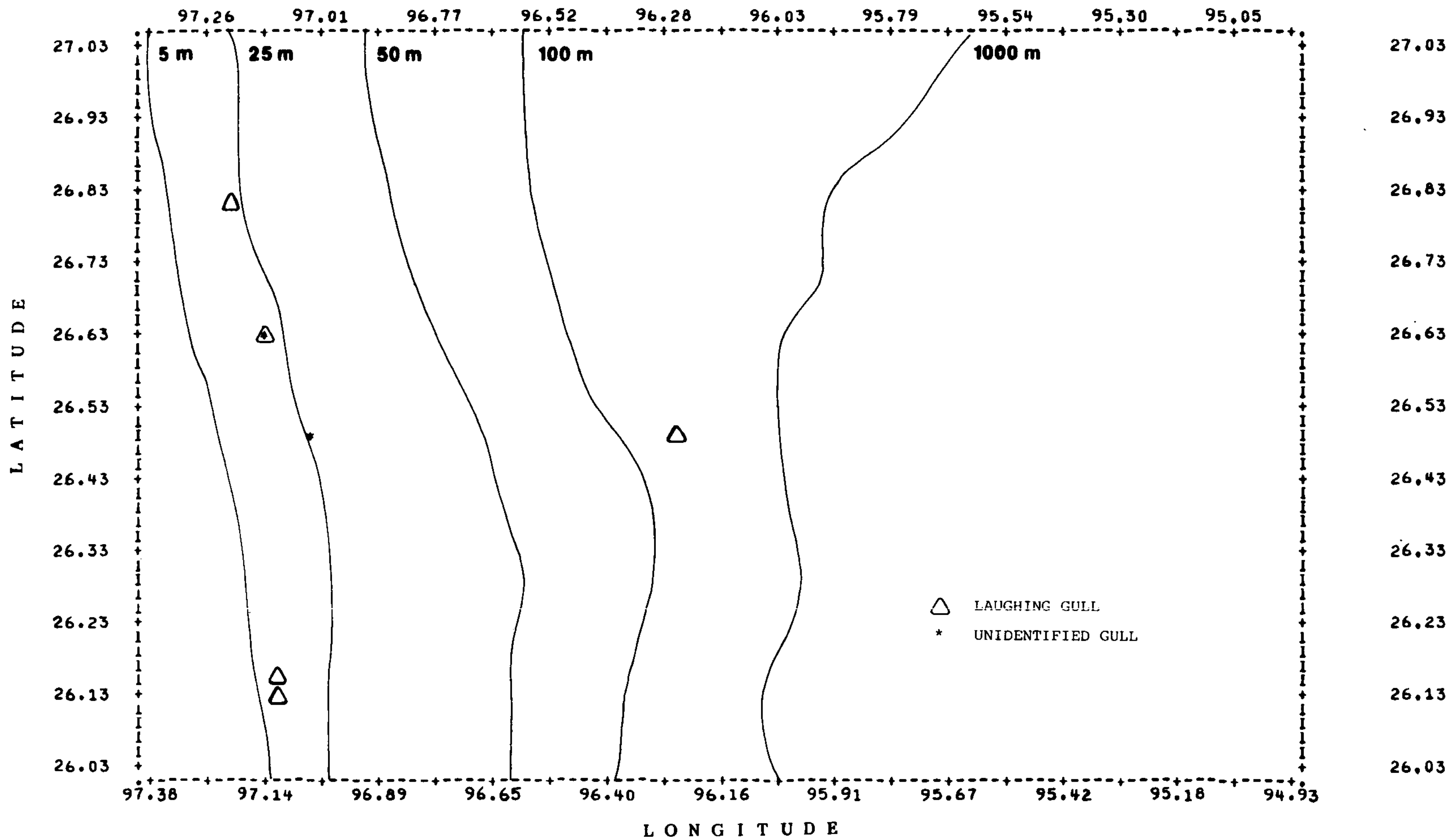
Map 25. Groups of unidentified dark terns sighted in STEX during August.



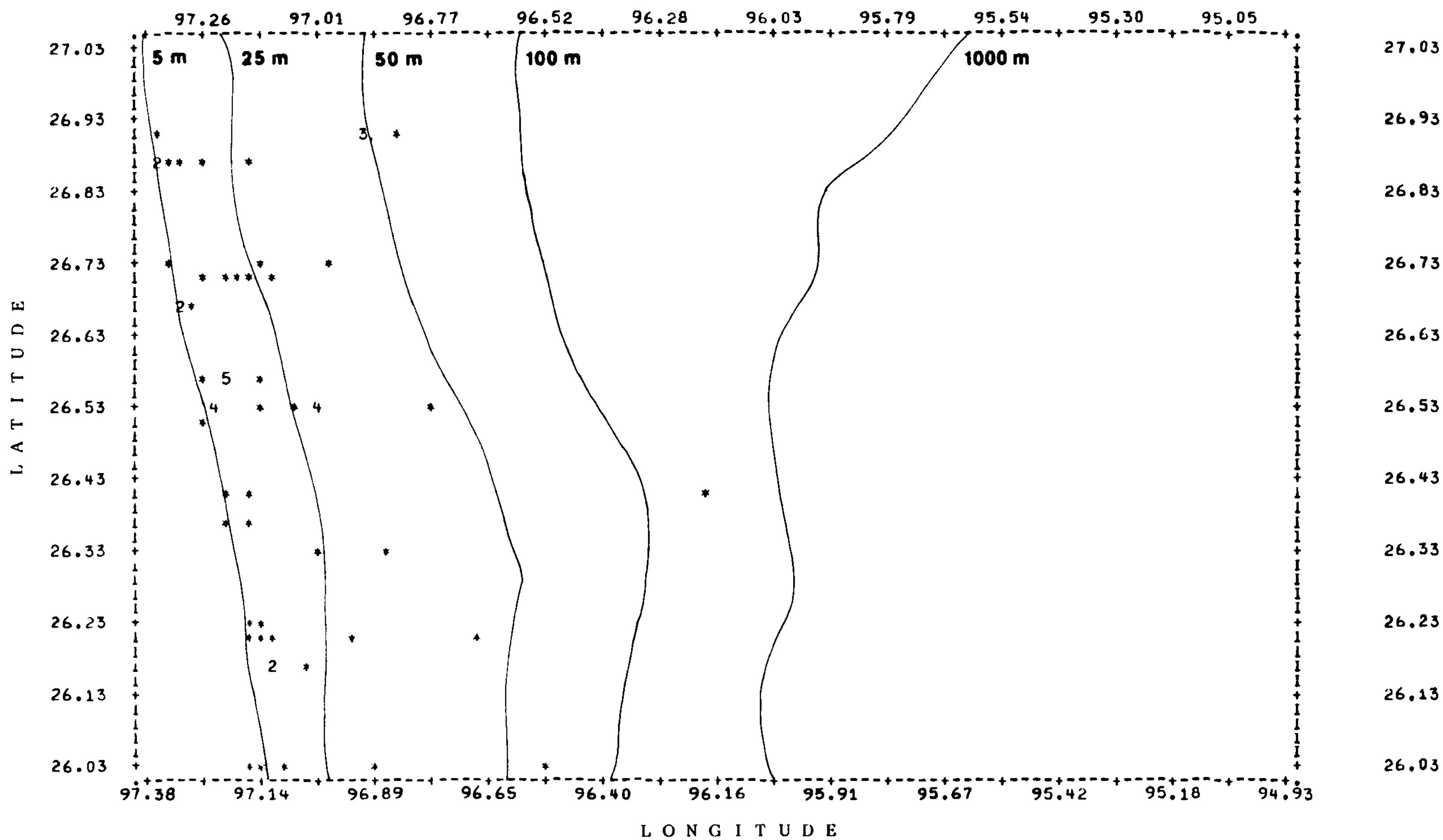
Map 26. Groups of royal terns sighted in STEX during August. Numbers indicate the number of sightings at a single map point.



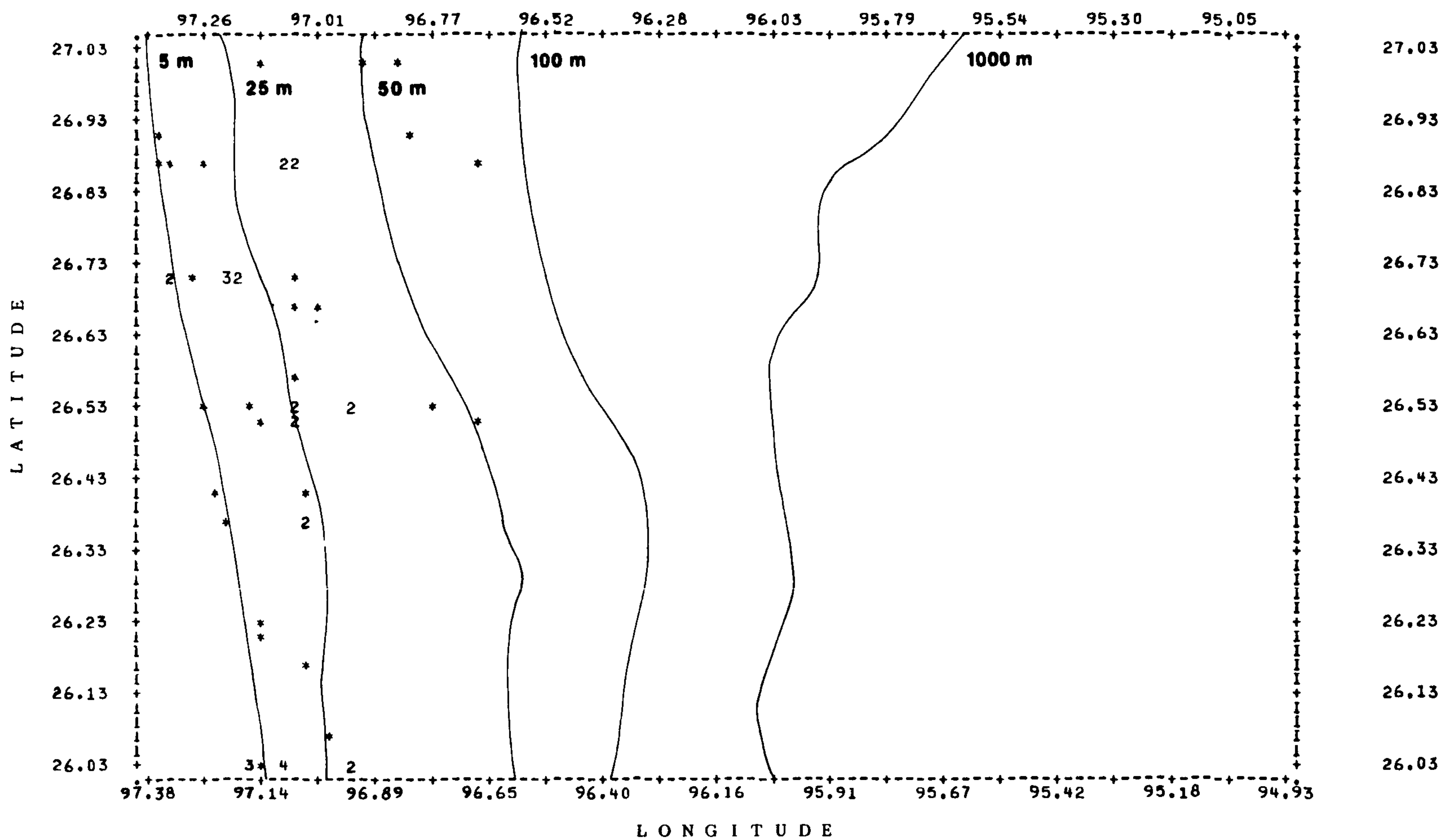
Map 27. Groups of unidentified pale terns sighted in STEX during August. Numbers indicate the number of sightings at a single map point.



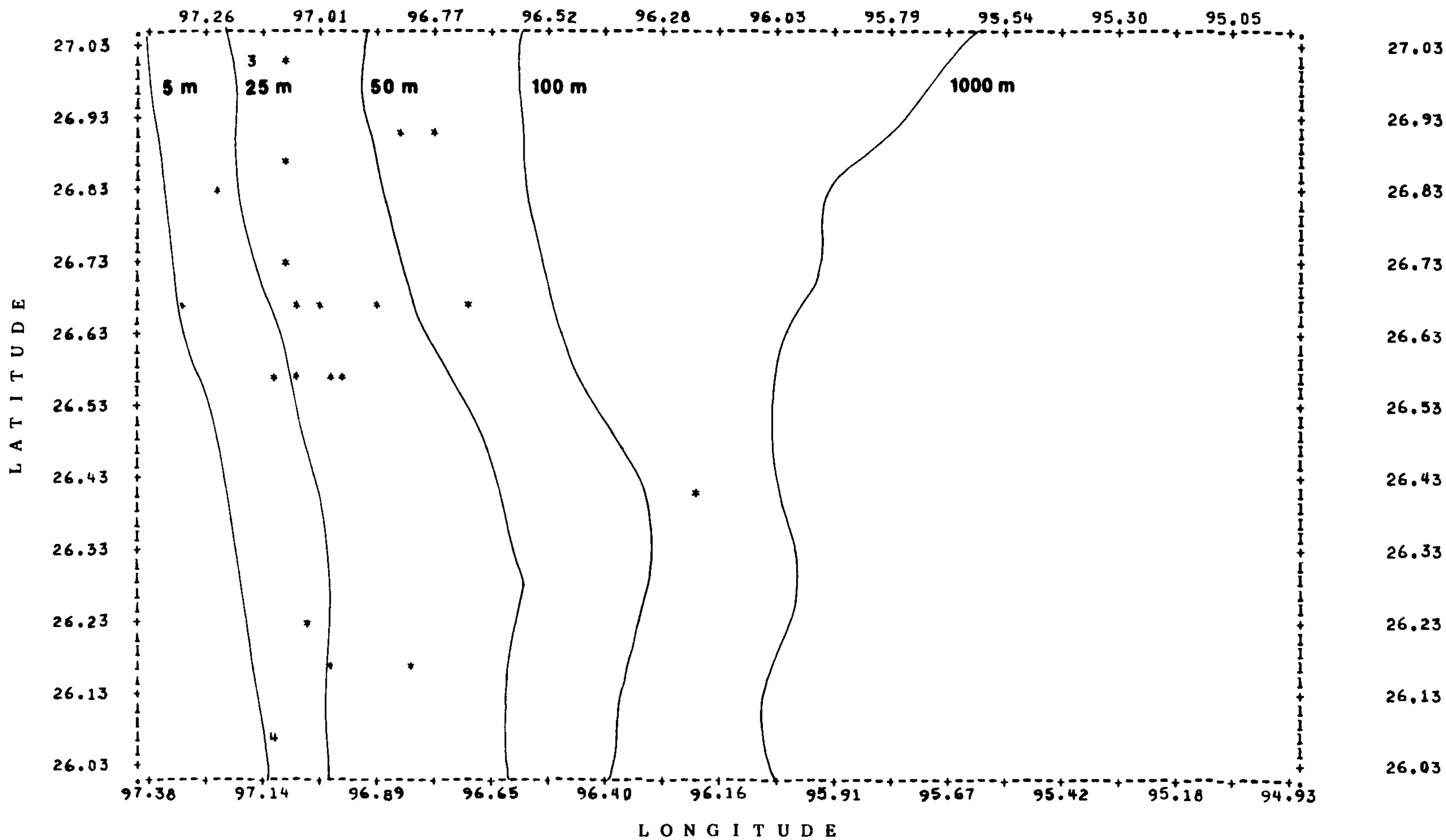
Map 28. Groups of laughing gulls and unidentified gulls sighted in STEX during August.



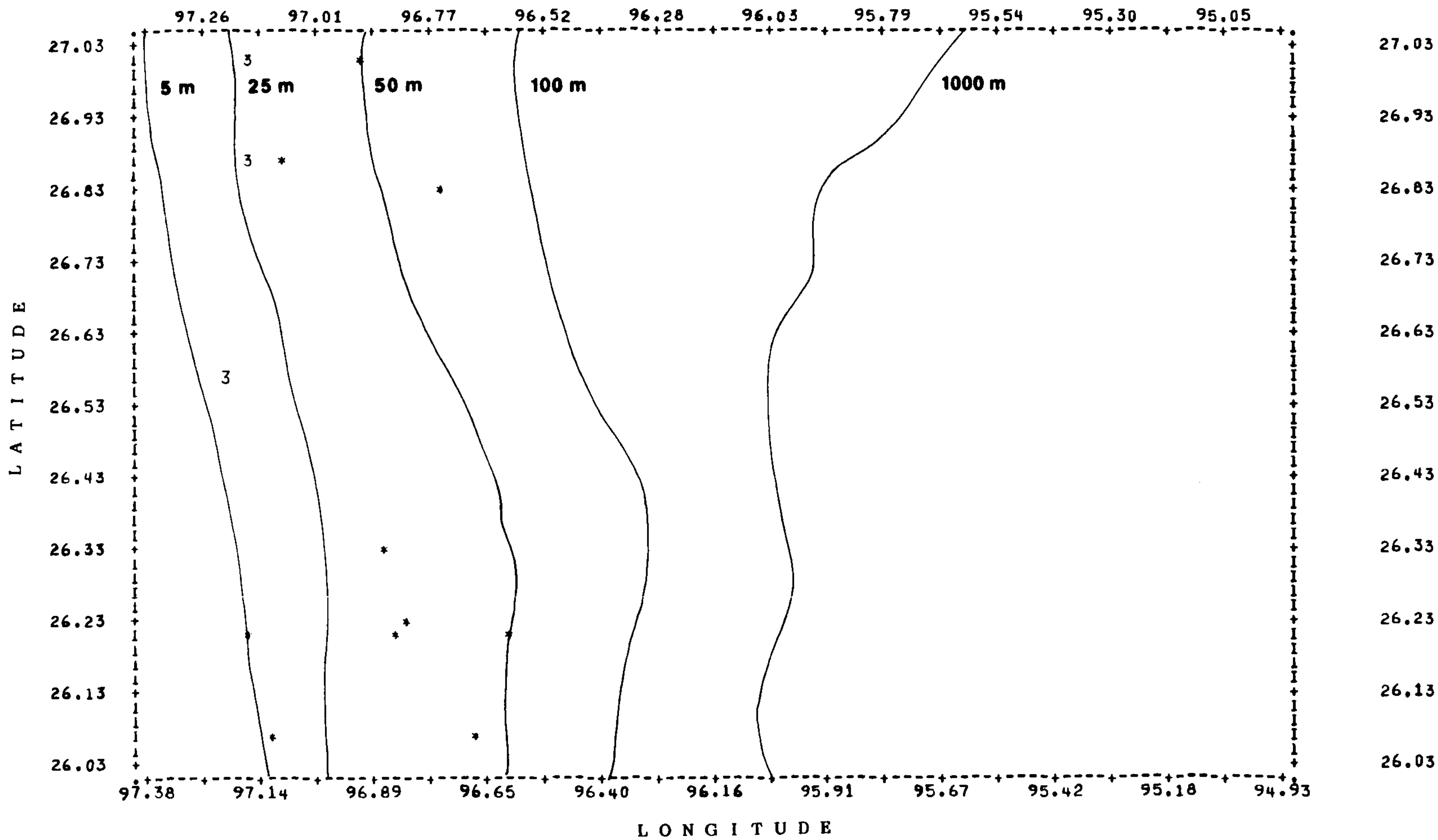
Map 29. Groups of royal terns sighted in STEX during November. Numbers indicate the number of sightings at a single map point.



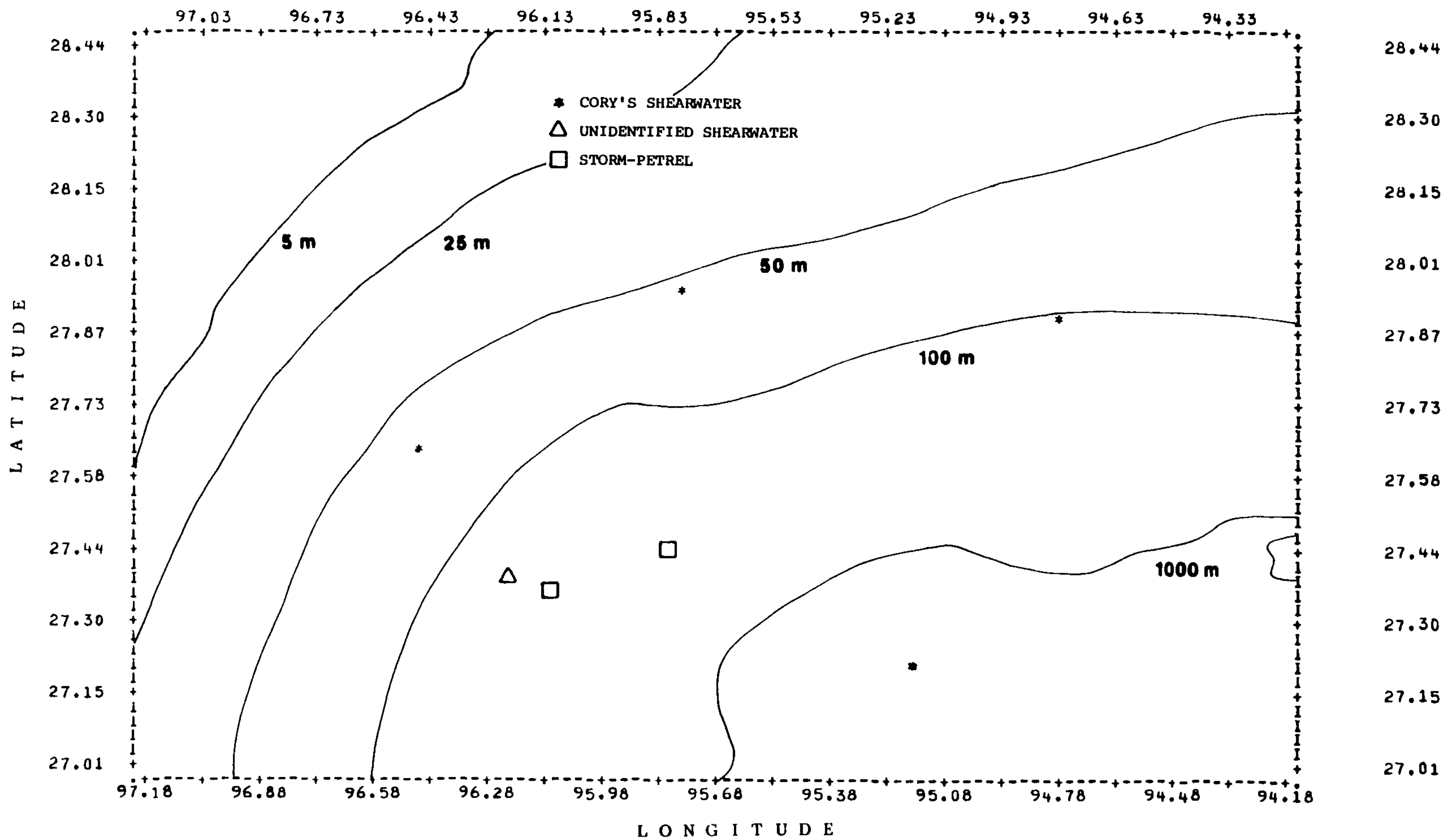
Map 30. Groups of unidentified terns sighted in STEX during November. Numbers indicate the number of sightings at a single map point.



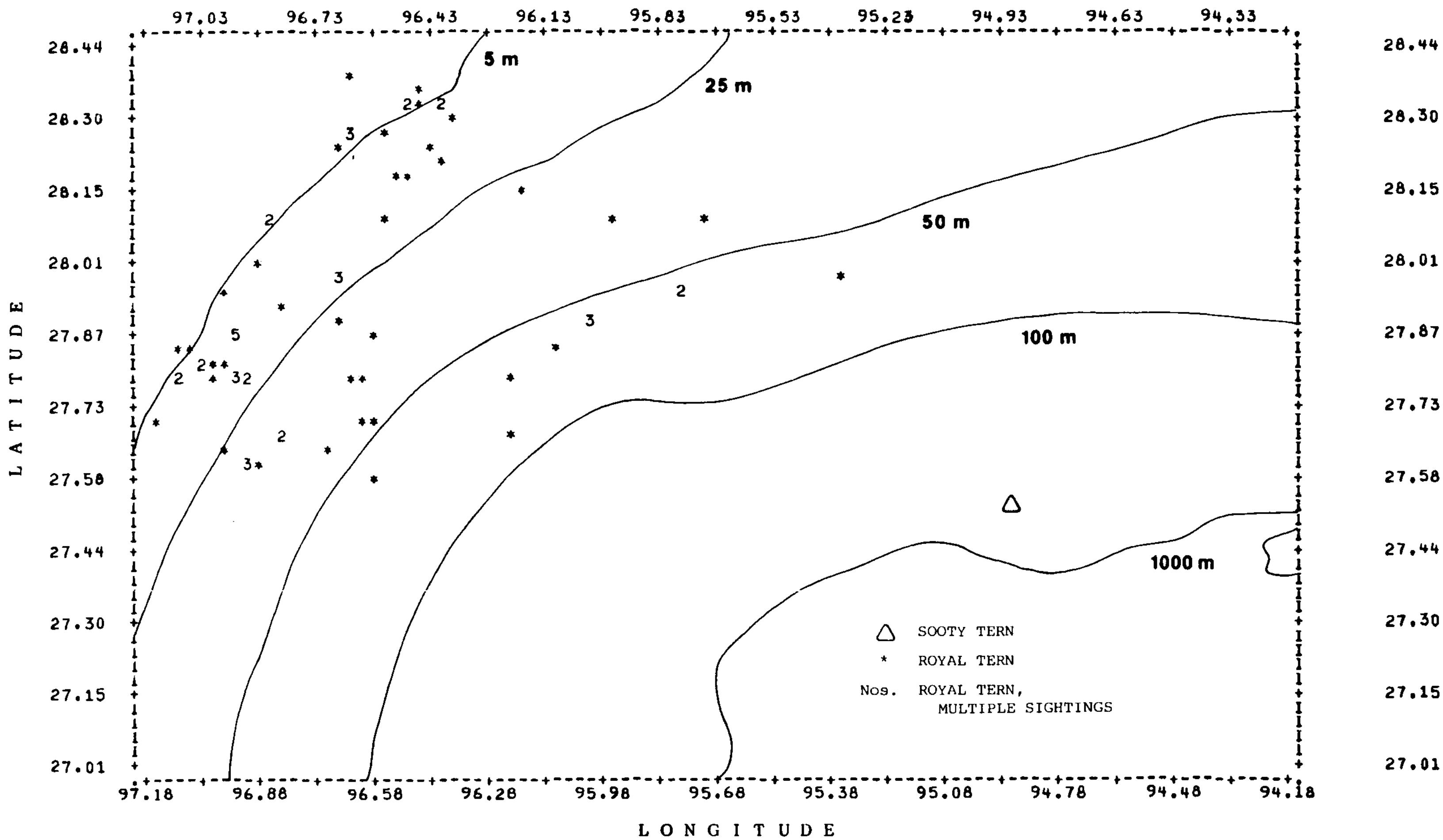
Map 31. Groups of herring gulls sighted in STEX during November. Numbers indicate the number of sightings at a single map point.



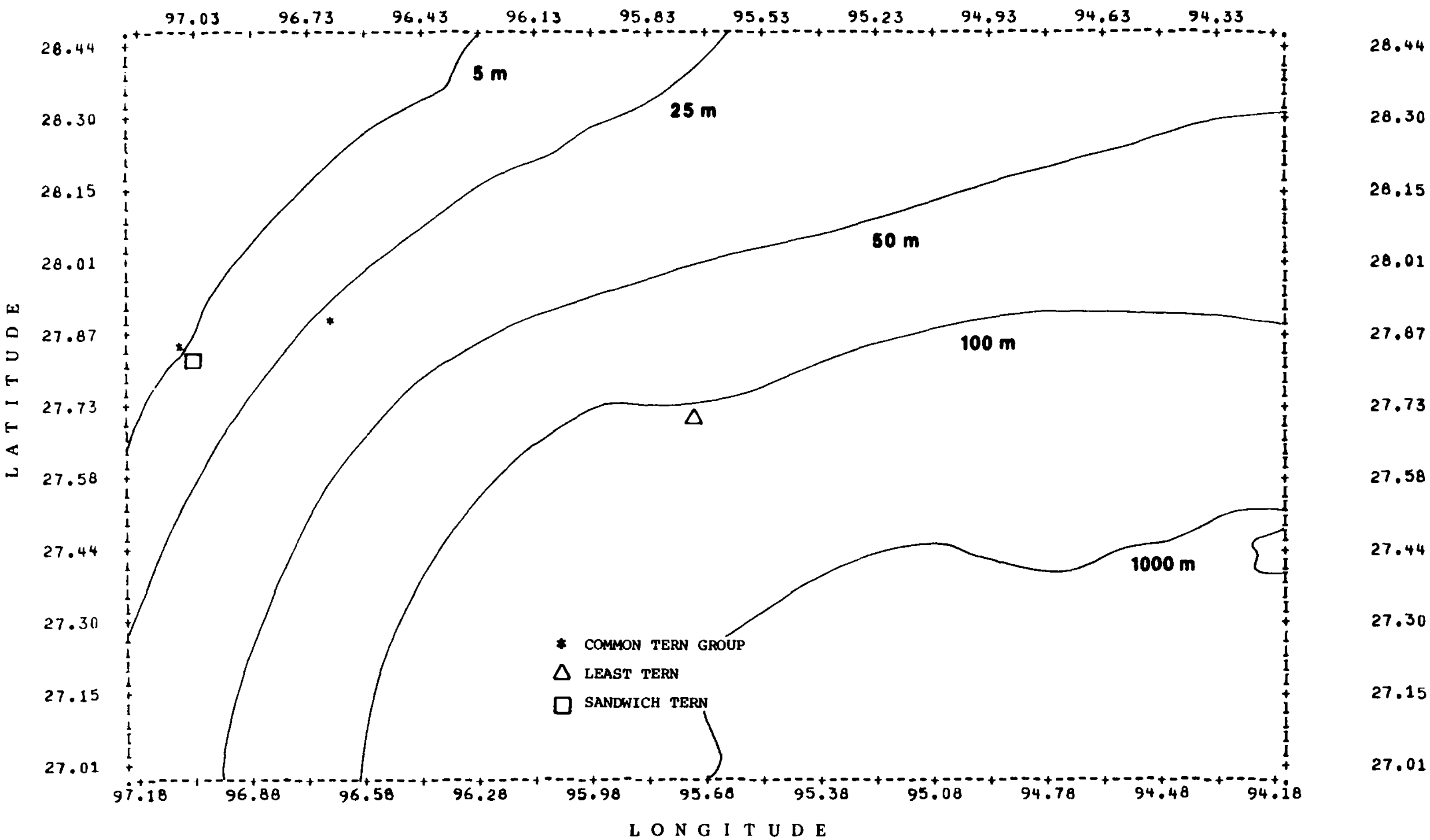
Map 32. Groups of unidentified gulls sighted in STEX during November. Numbers indicate the number of sightings at a single map point.



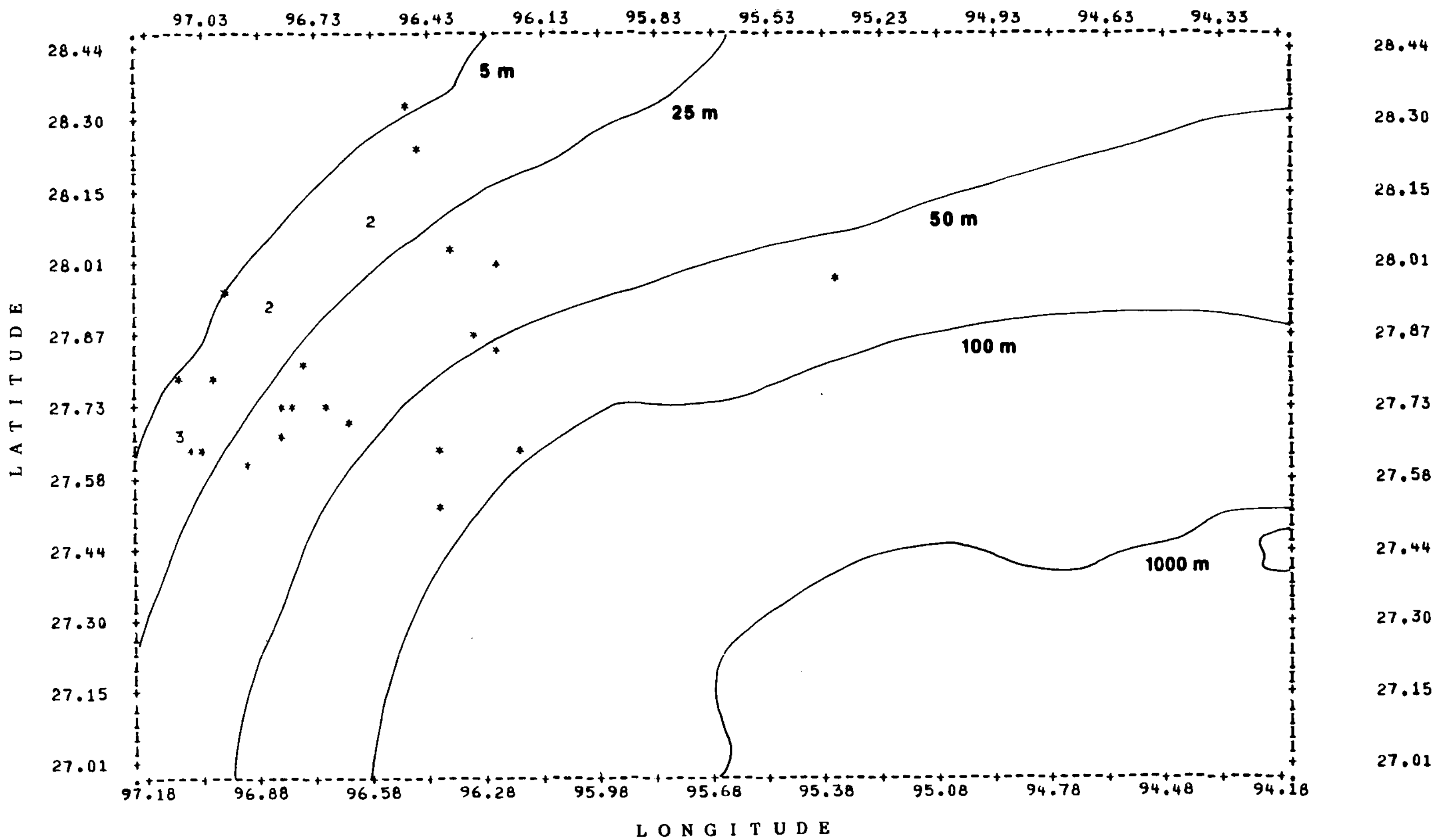
Map 33. Groups of Cory's shearwaters, unidentified shearwaters, and storm-petrels sighted in NTEX during August.



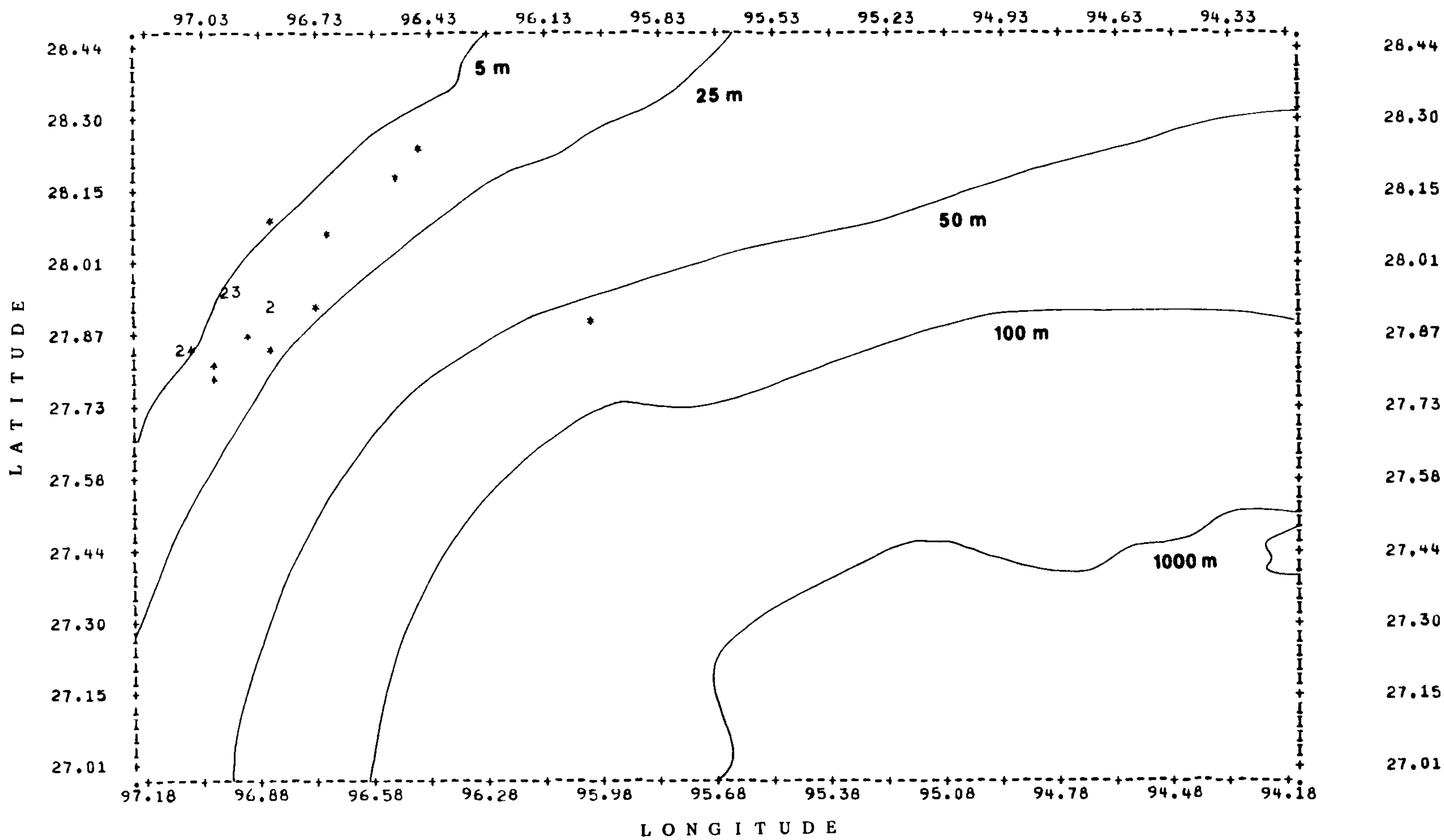
Map 34. Groups of sooty terns and royal terns sighted in NTEX during August.



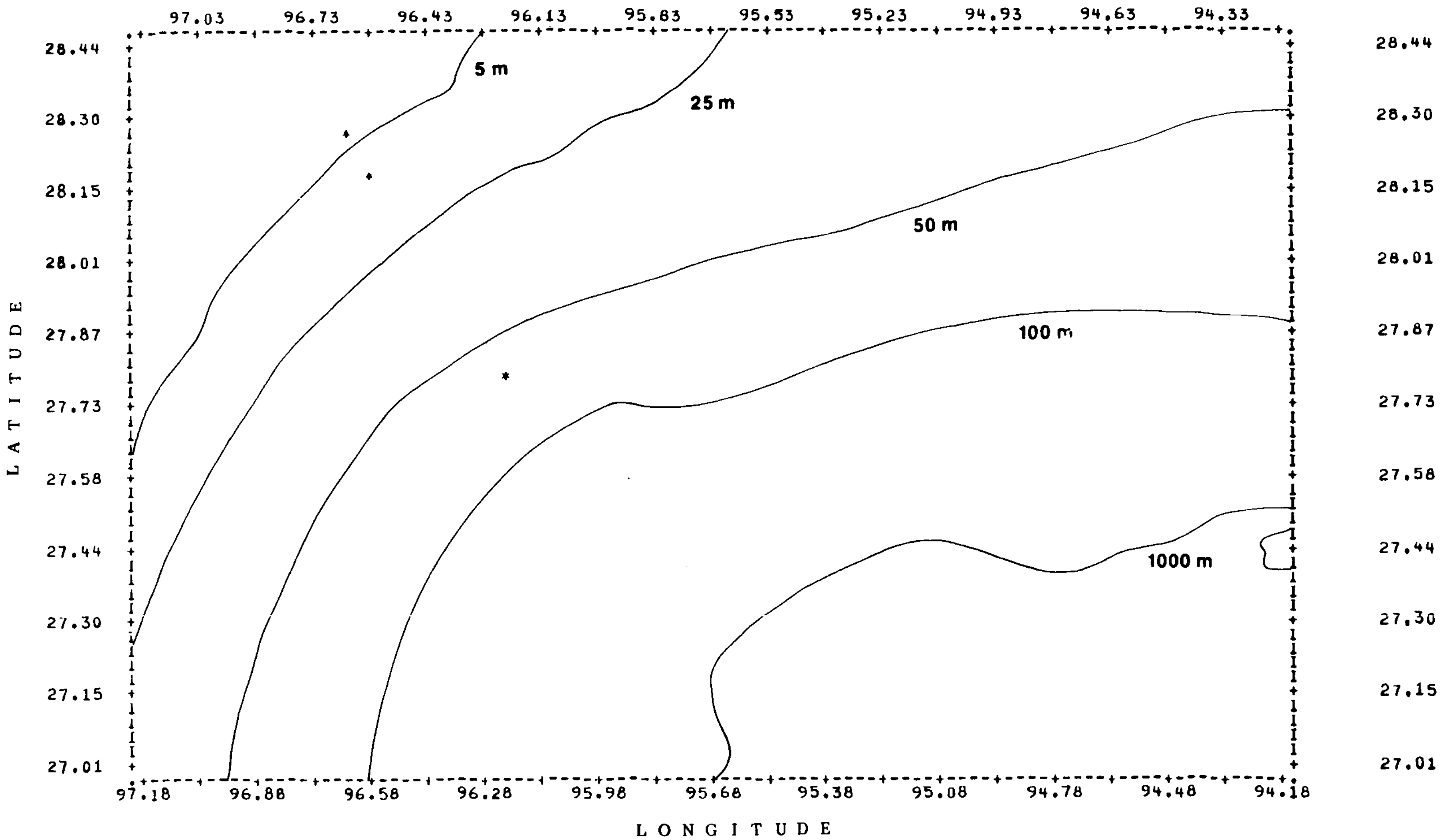
Map 35. Groups of common group, least, and Sandwich terns sighted in NTEX during August.



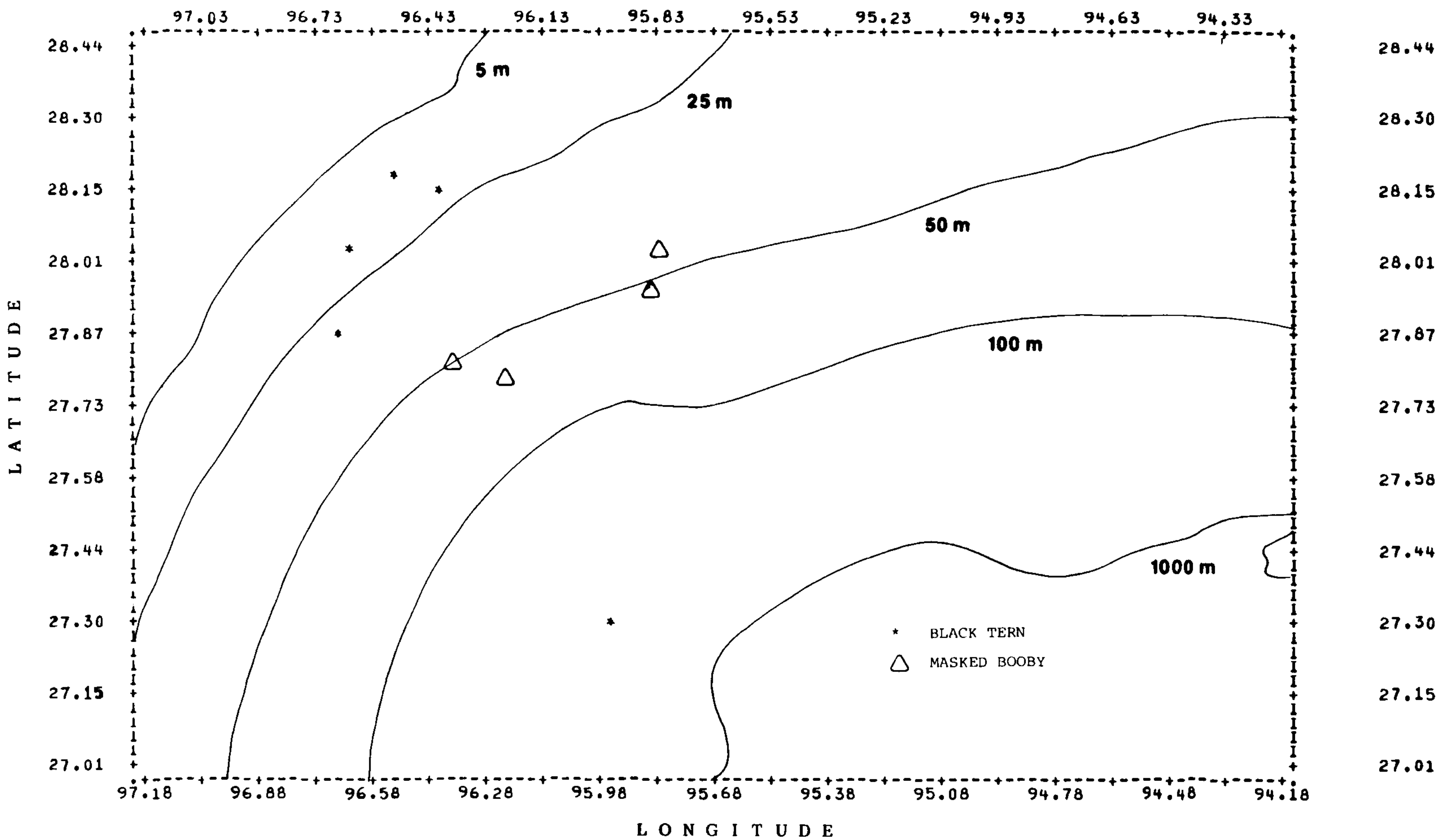
Map 36. Groups of unidentified pale terns sighted in NTEX during August. Numbers indicate the number of sightings at a single map point.



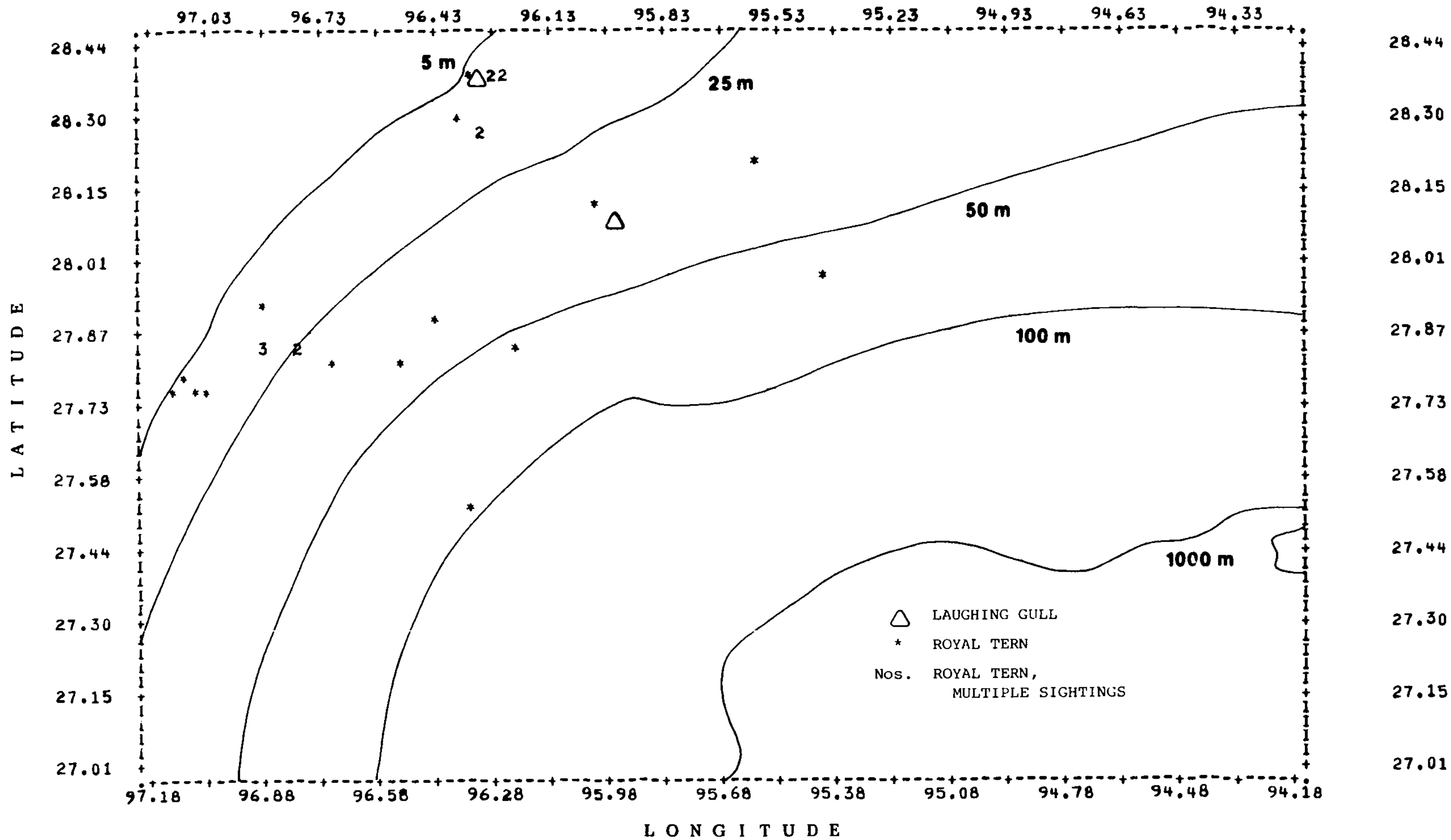
Map 37. Groups of laughing gulls sighted in NTEX during August. Numbers indicate the number of sightings at a single map point.



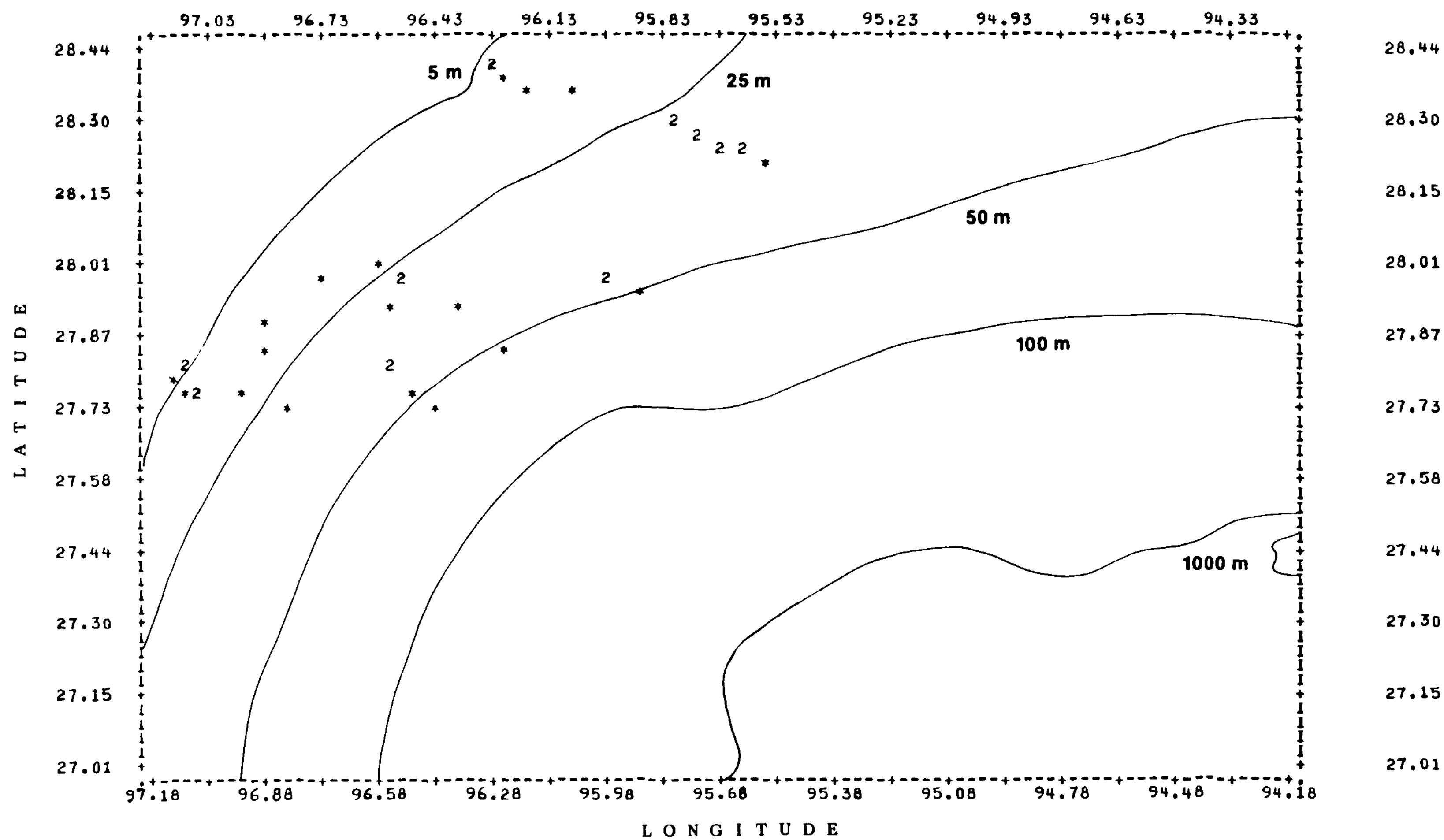
Map 38. Groups of magnificent frigatebirds sighted in NTEX during August.



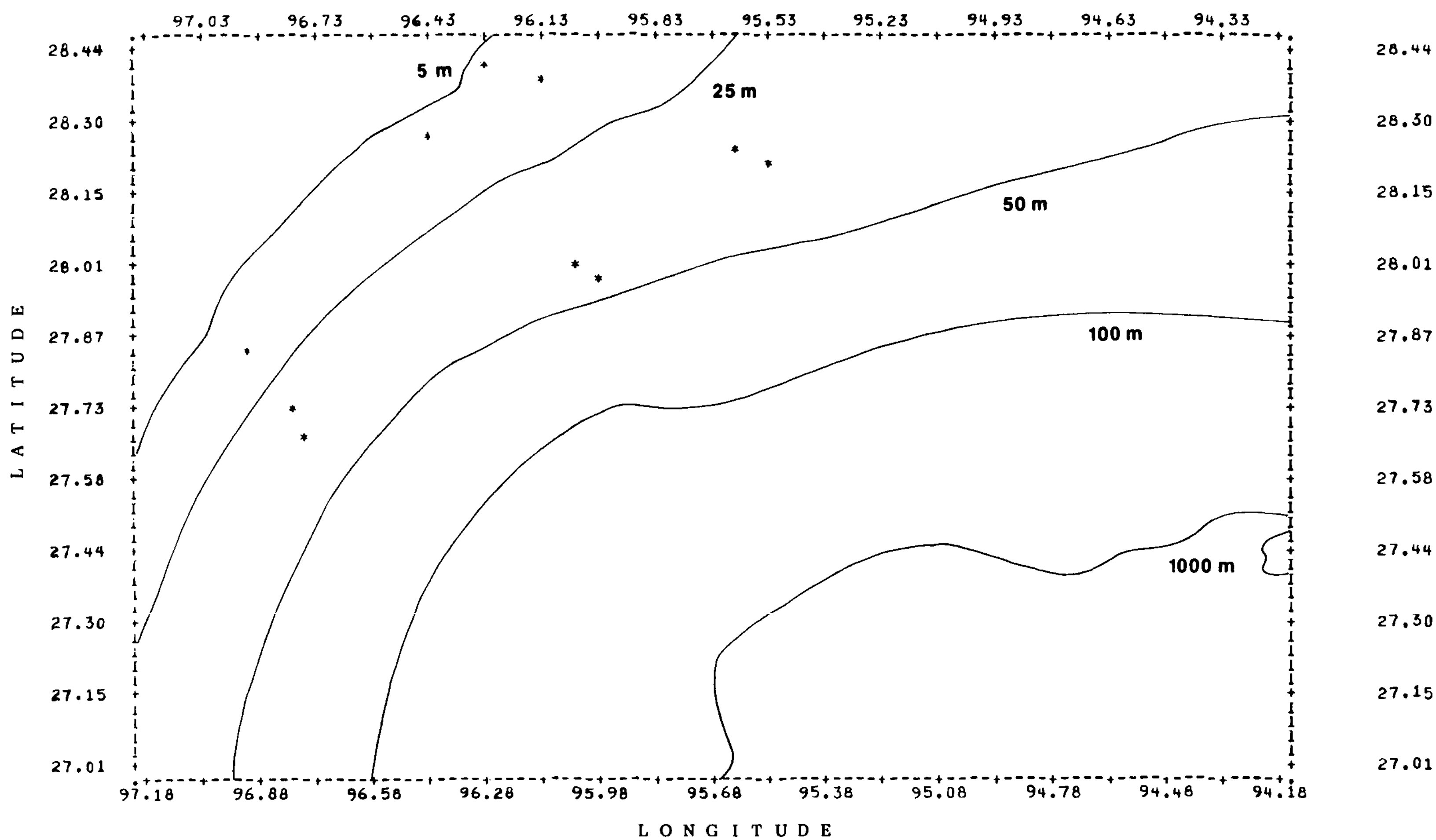
Map 39. Groups of black terns and masked boobies sighted in NTEX during August.



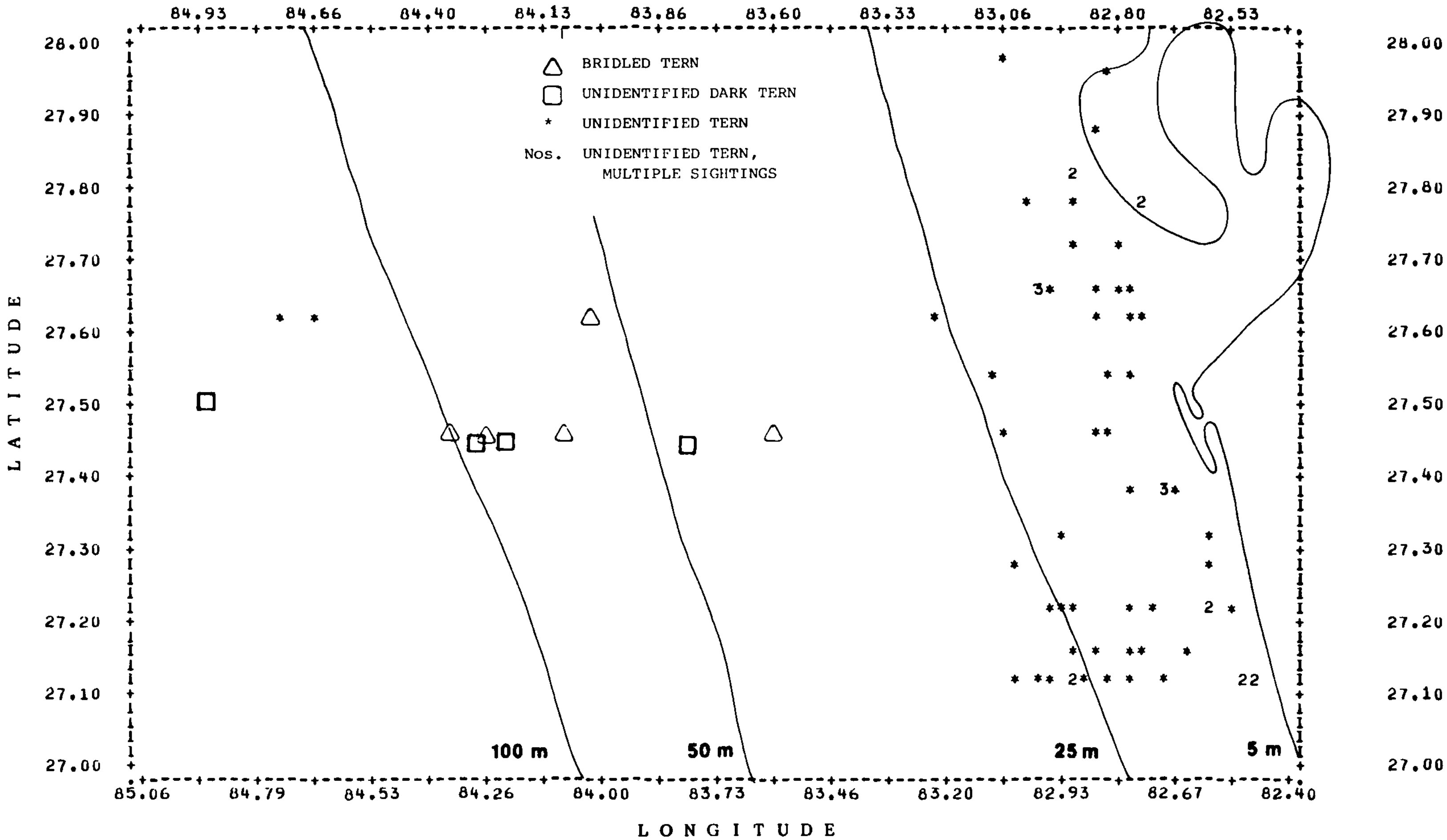
Map 40. Groups of laughing gulls and royal terns sighted in NTEX during November.



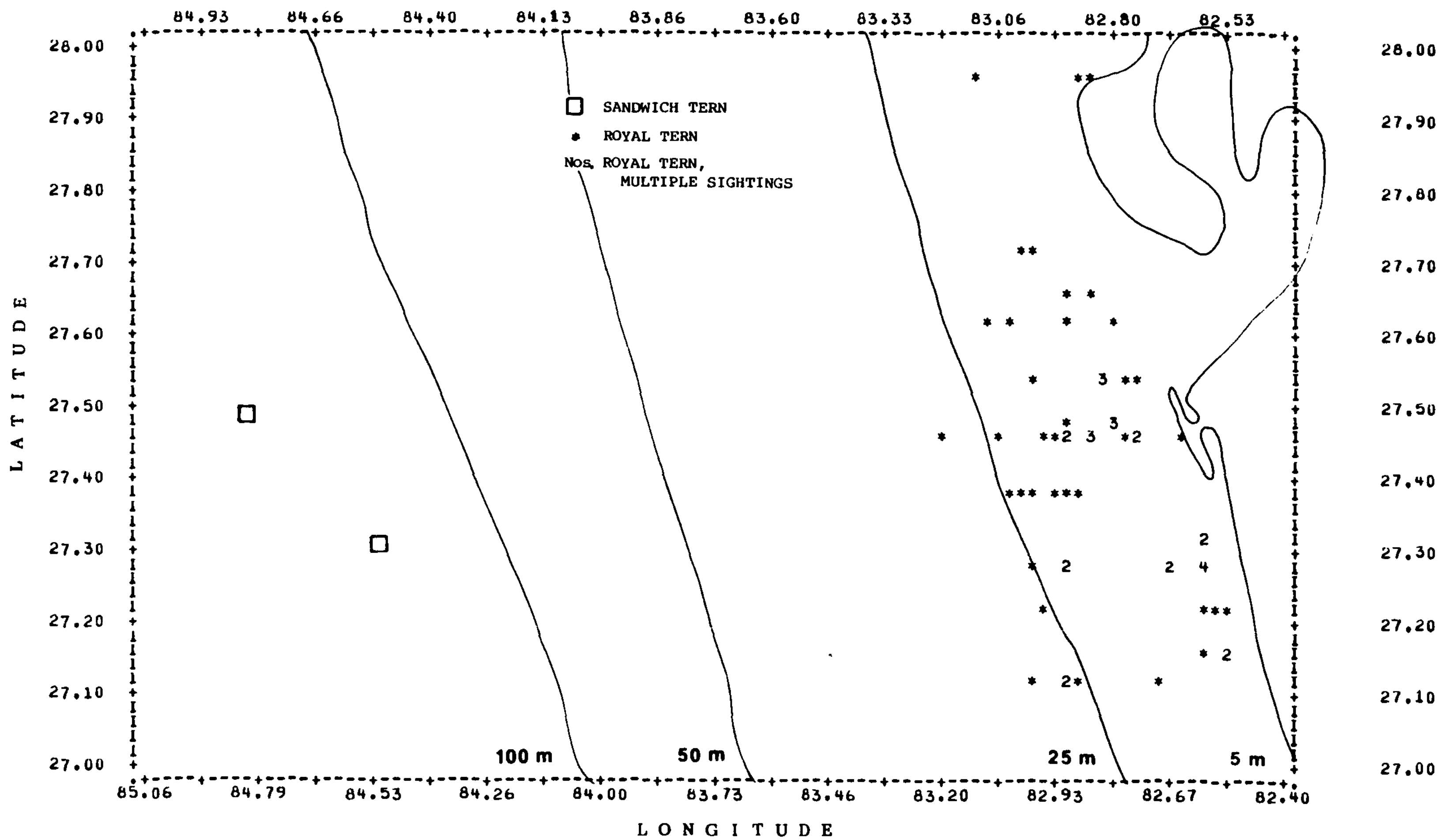
Map 41. Groups of herring gulls sighted in NTEX during November. Numbers indicate the number of sightings at a single map point.



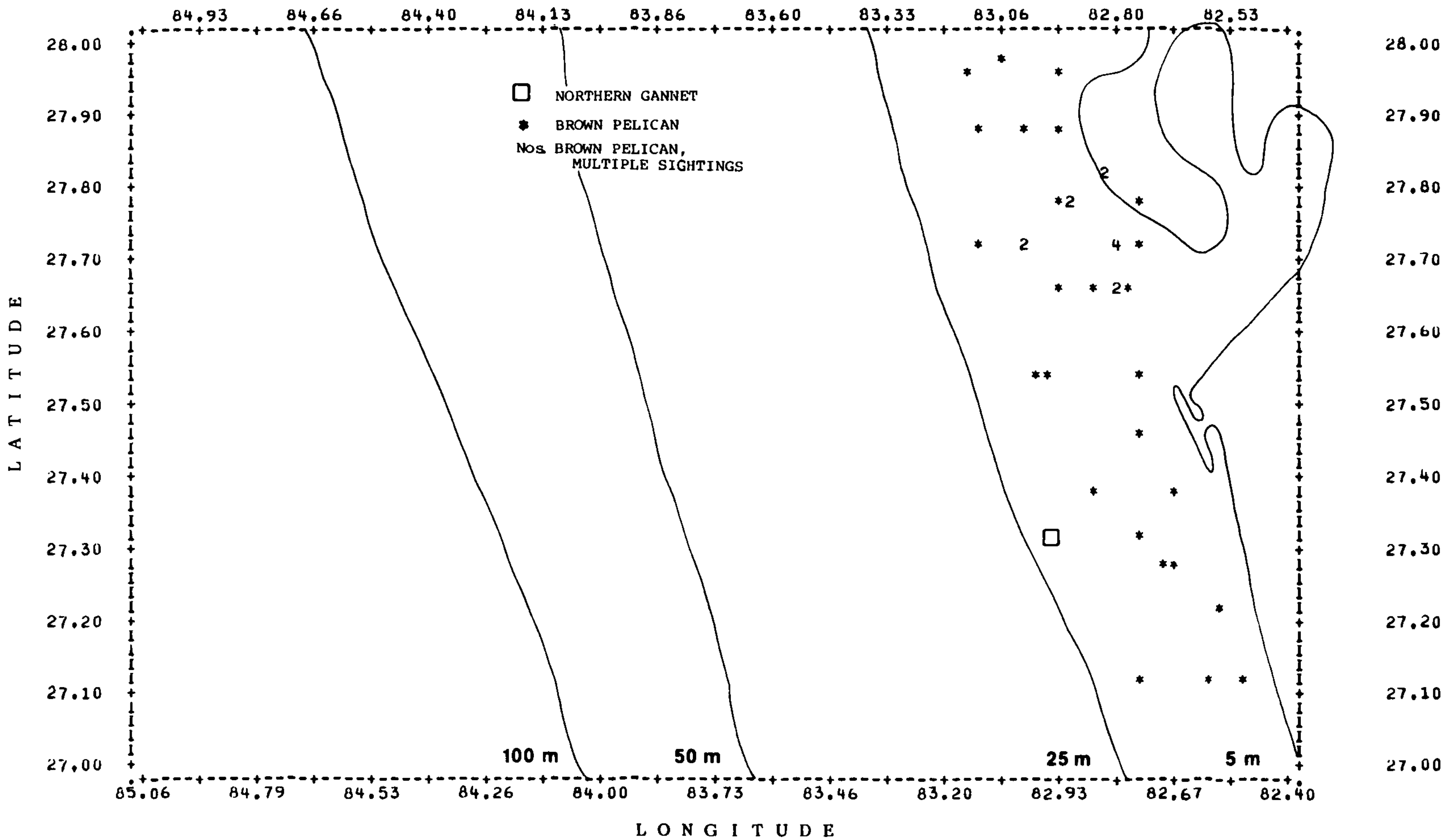
Map 42. Groups of unidentified gulls sighted in NTEX during November.



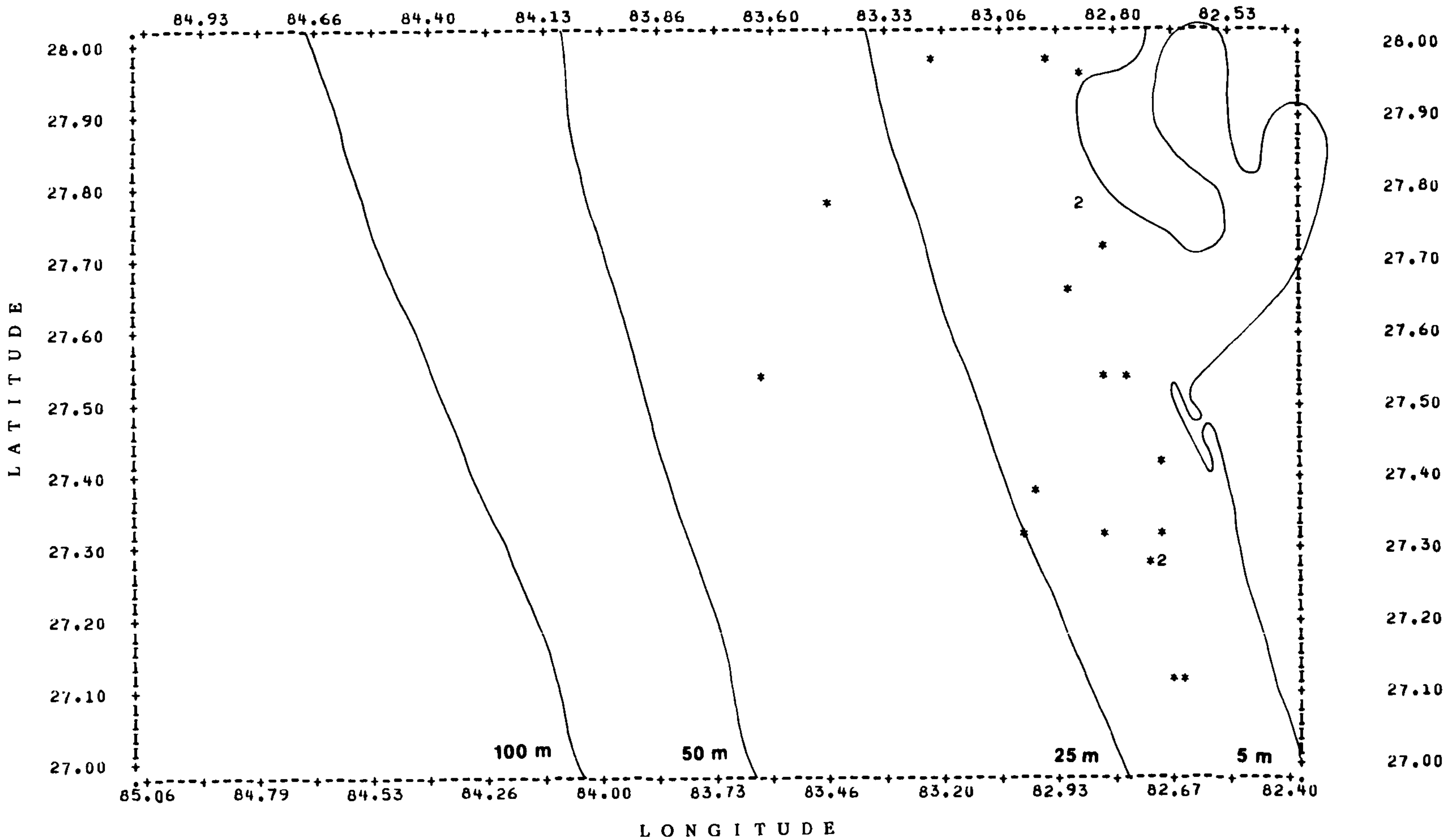
Map 43. Groups of bridled terns, unidentified dark terns, and unidentified terns sighted in NFLA during August.



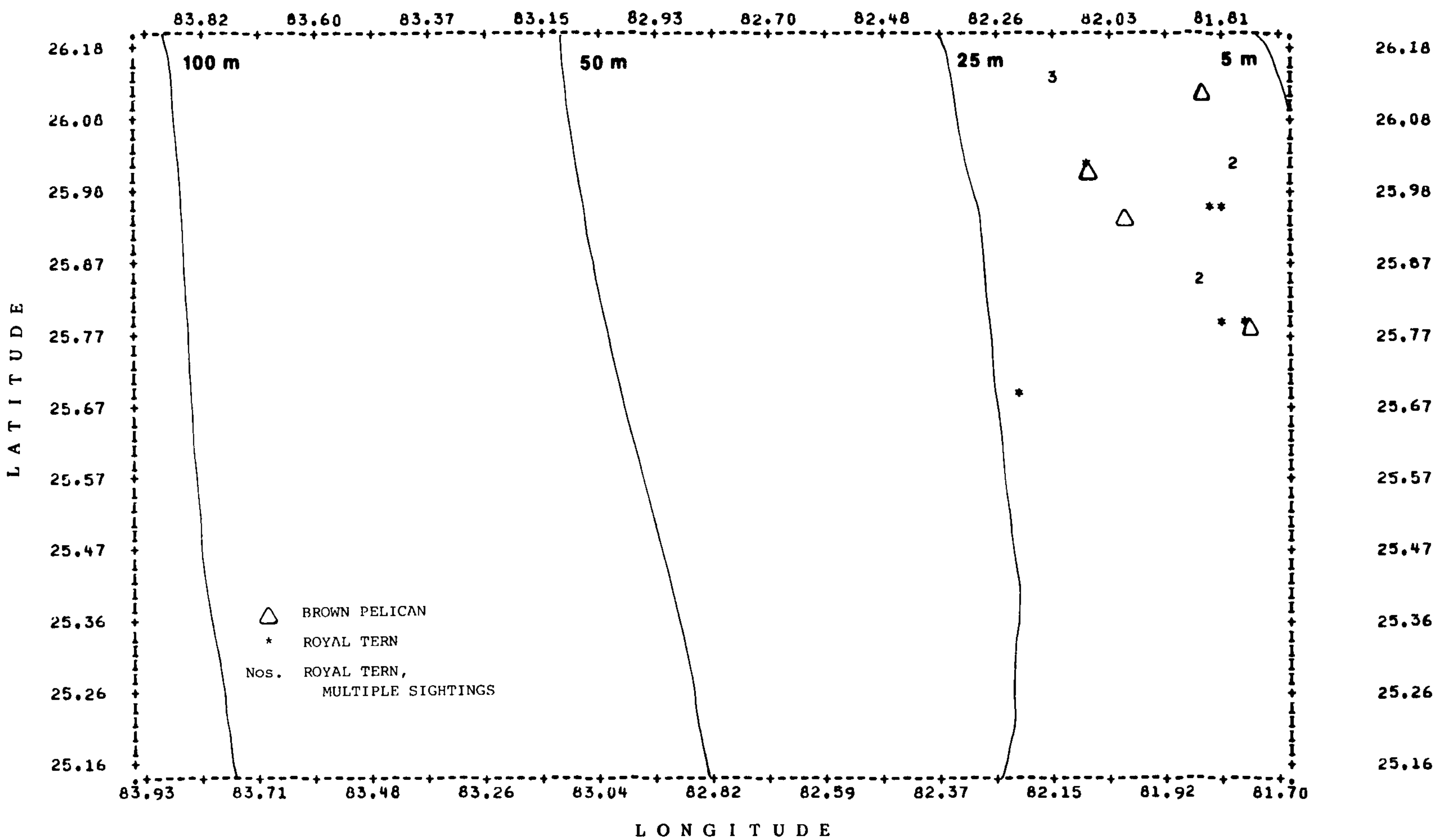
Map 44. Groups of Sandwich terns and royal terns sighted in NFLA during August.



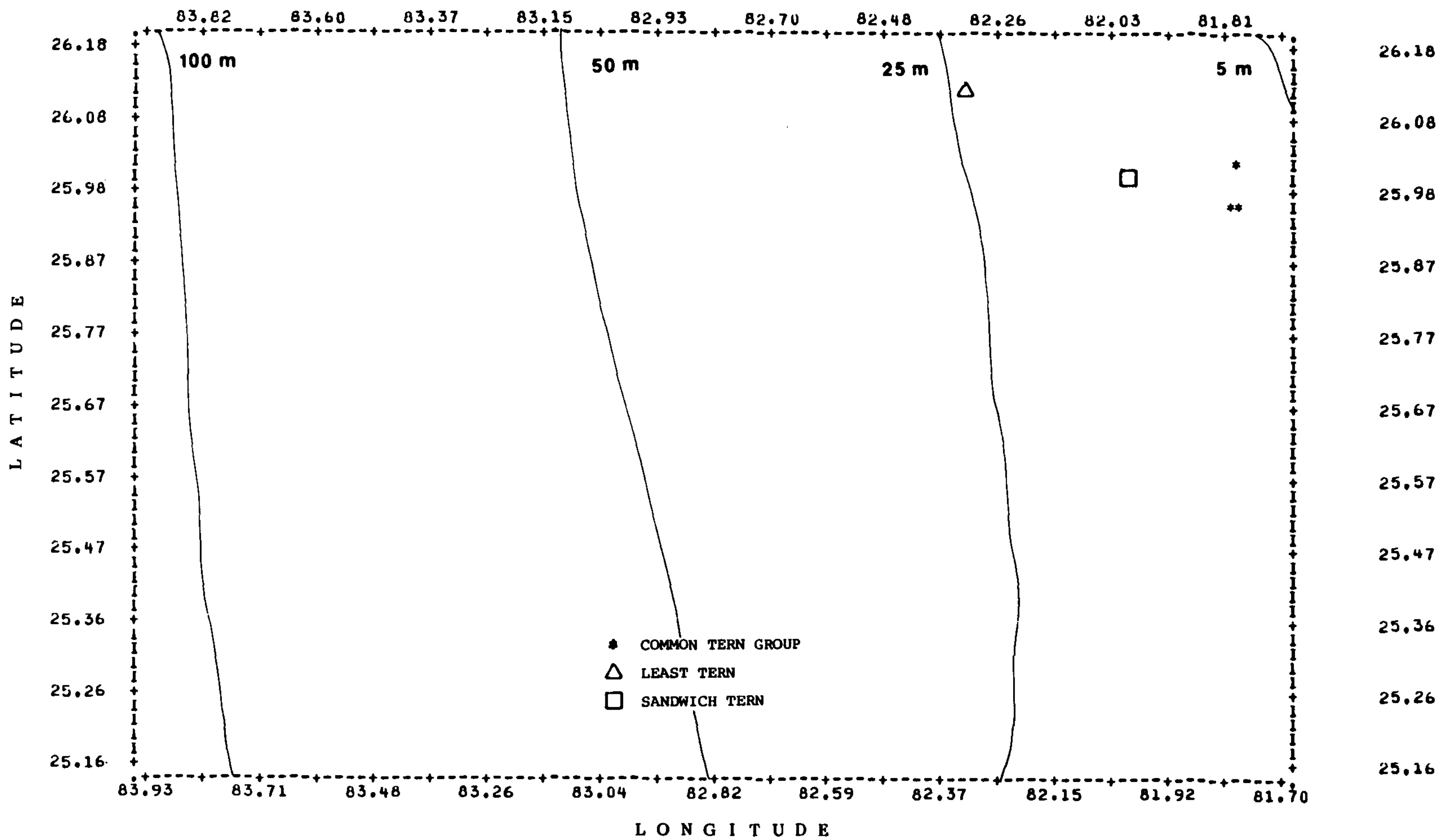
Map 45. Groups of northern gannets and brown pelicans sighted in NFLA during August.



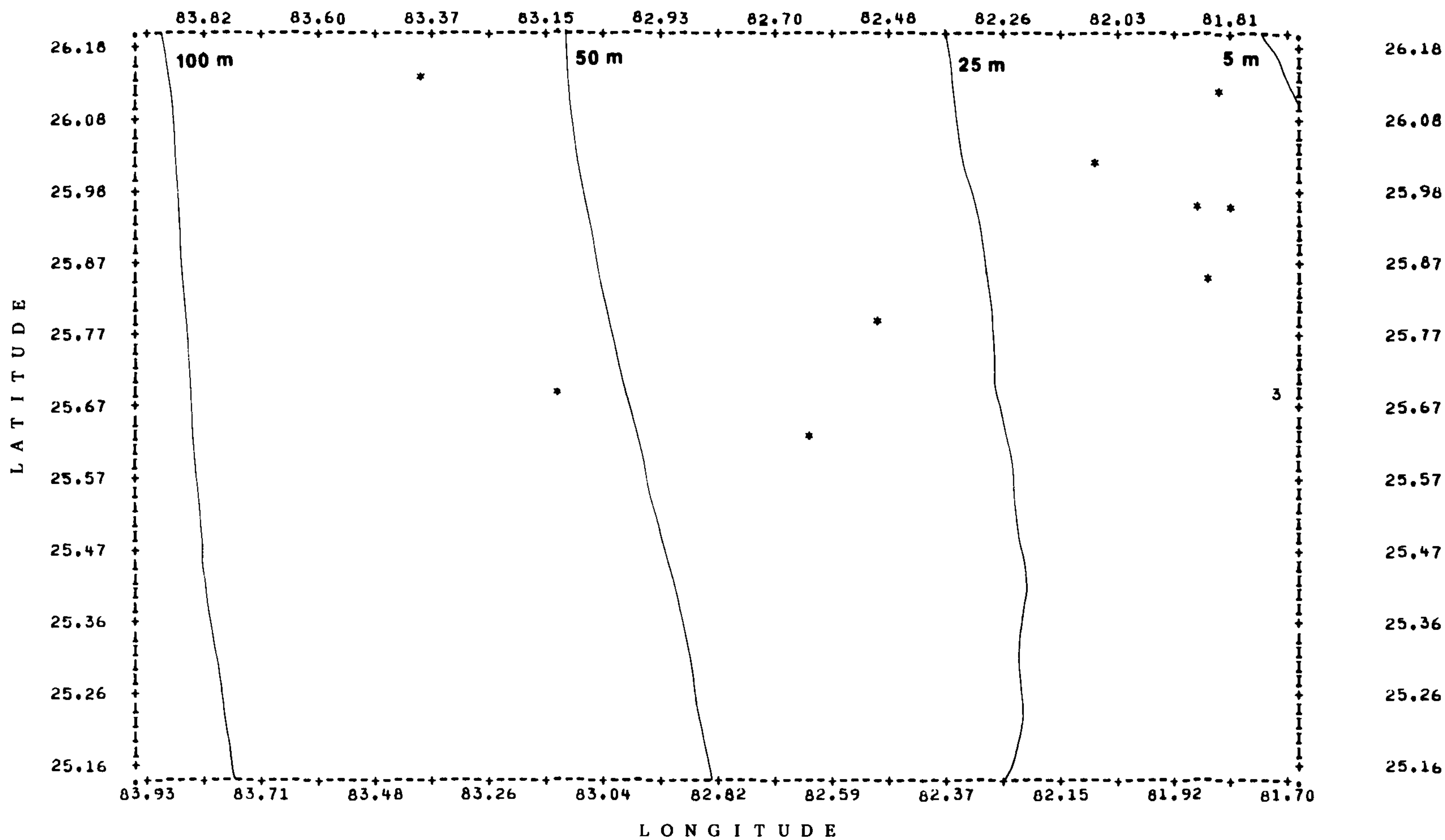
Map 46. Groups of magnificent frigatebirds sighted in NFLA during August. Numbers indicate the number of sightings at a single map point.



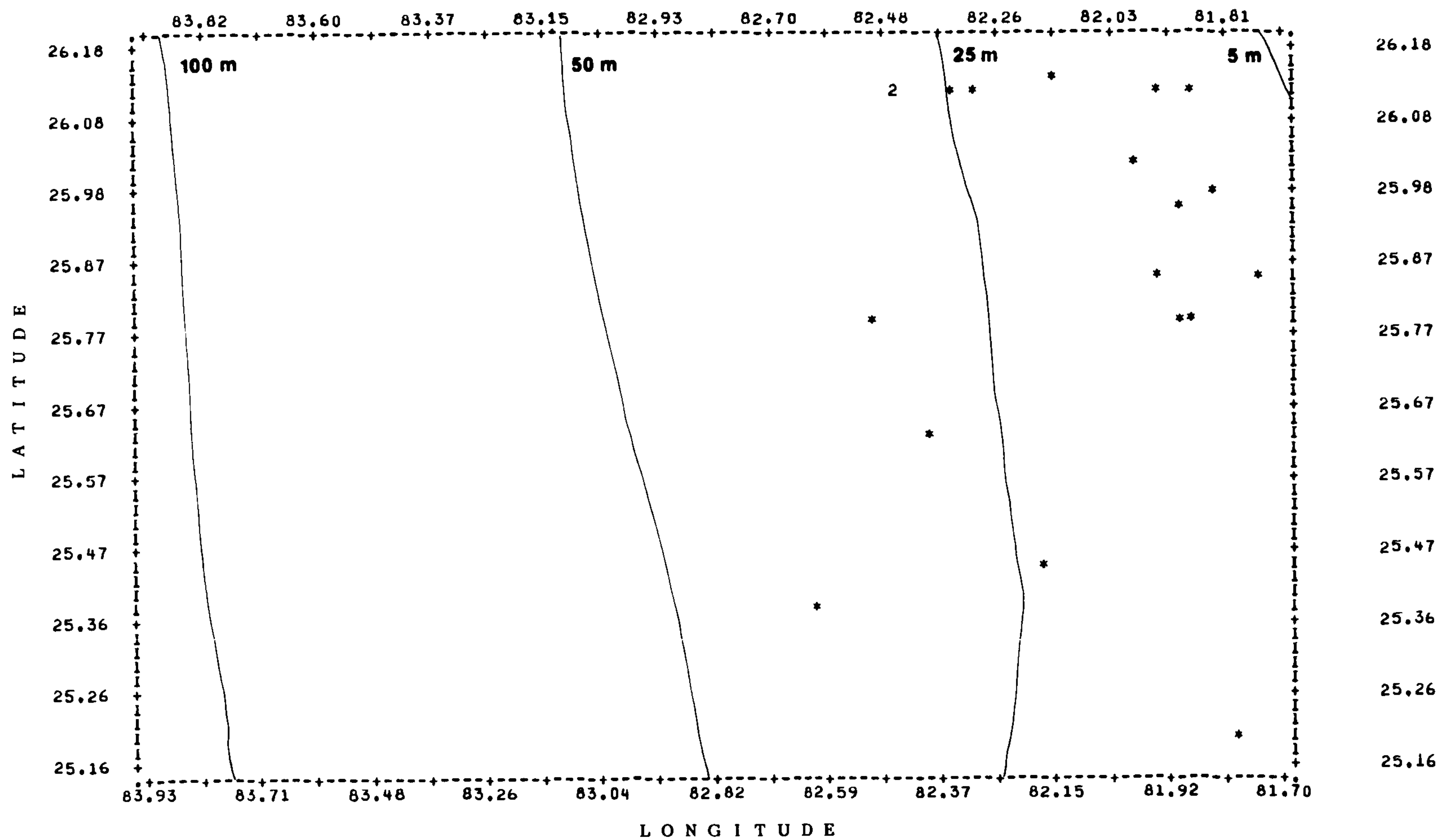
Map 47. Groups of brown pelicans and royal terns sighted in SFLA during August.



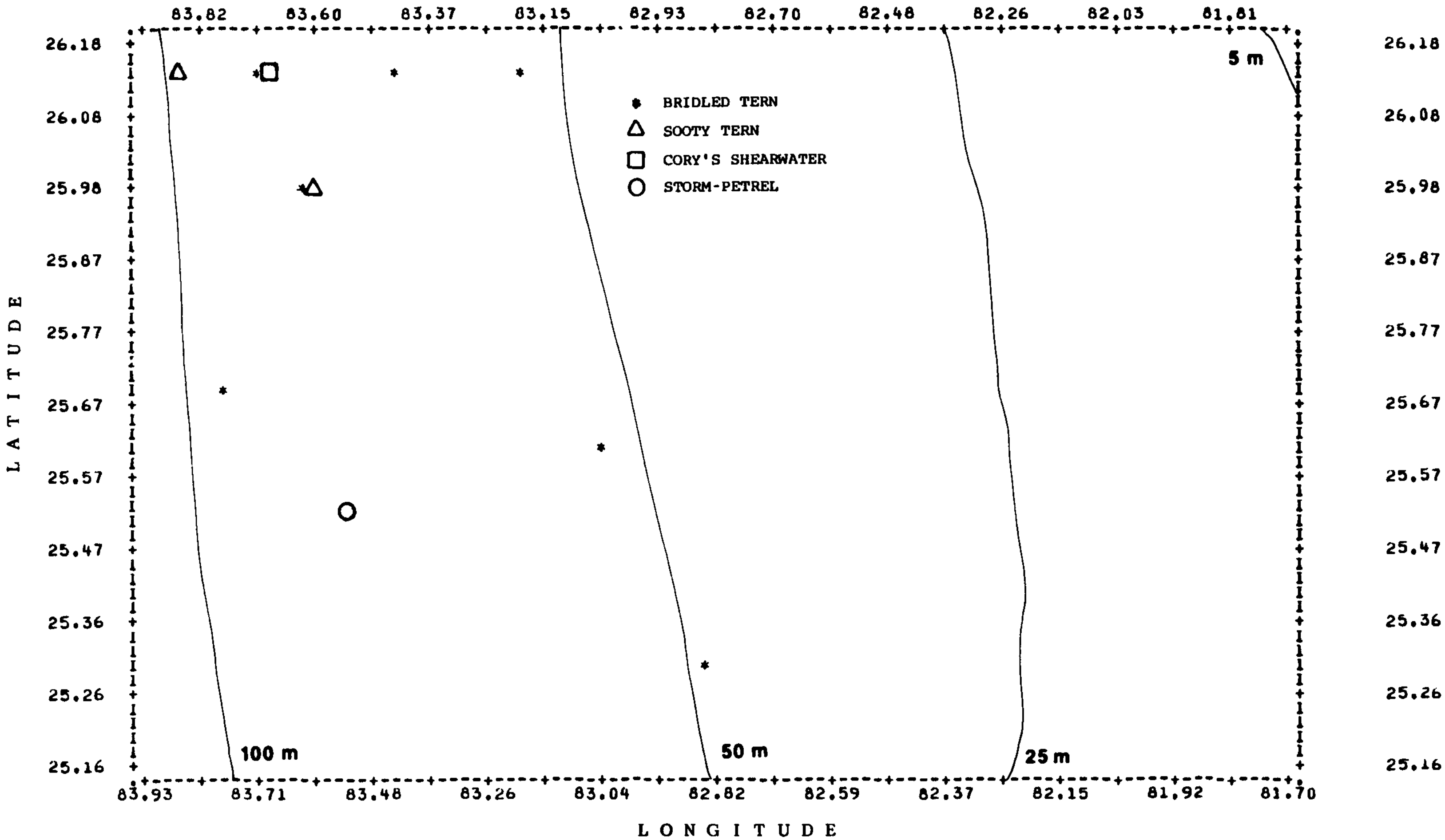
Map 48. Groups of common group, least, and Sandwich terns sighted in SFLA during August.



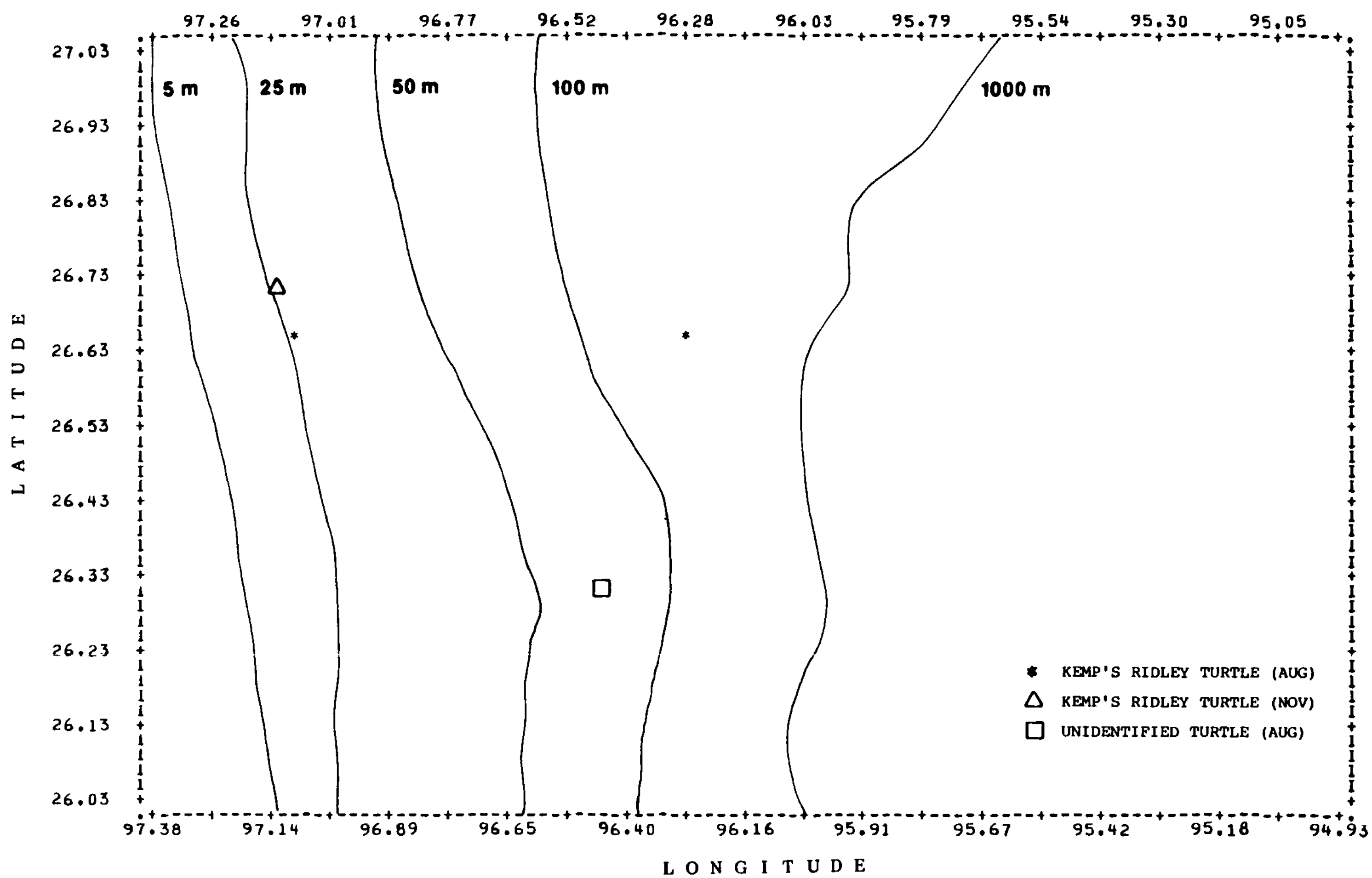
Map 49. Groups of unidentified terns sighted in SFLA during August. Numbers indicate the number of sightings at a single map point.



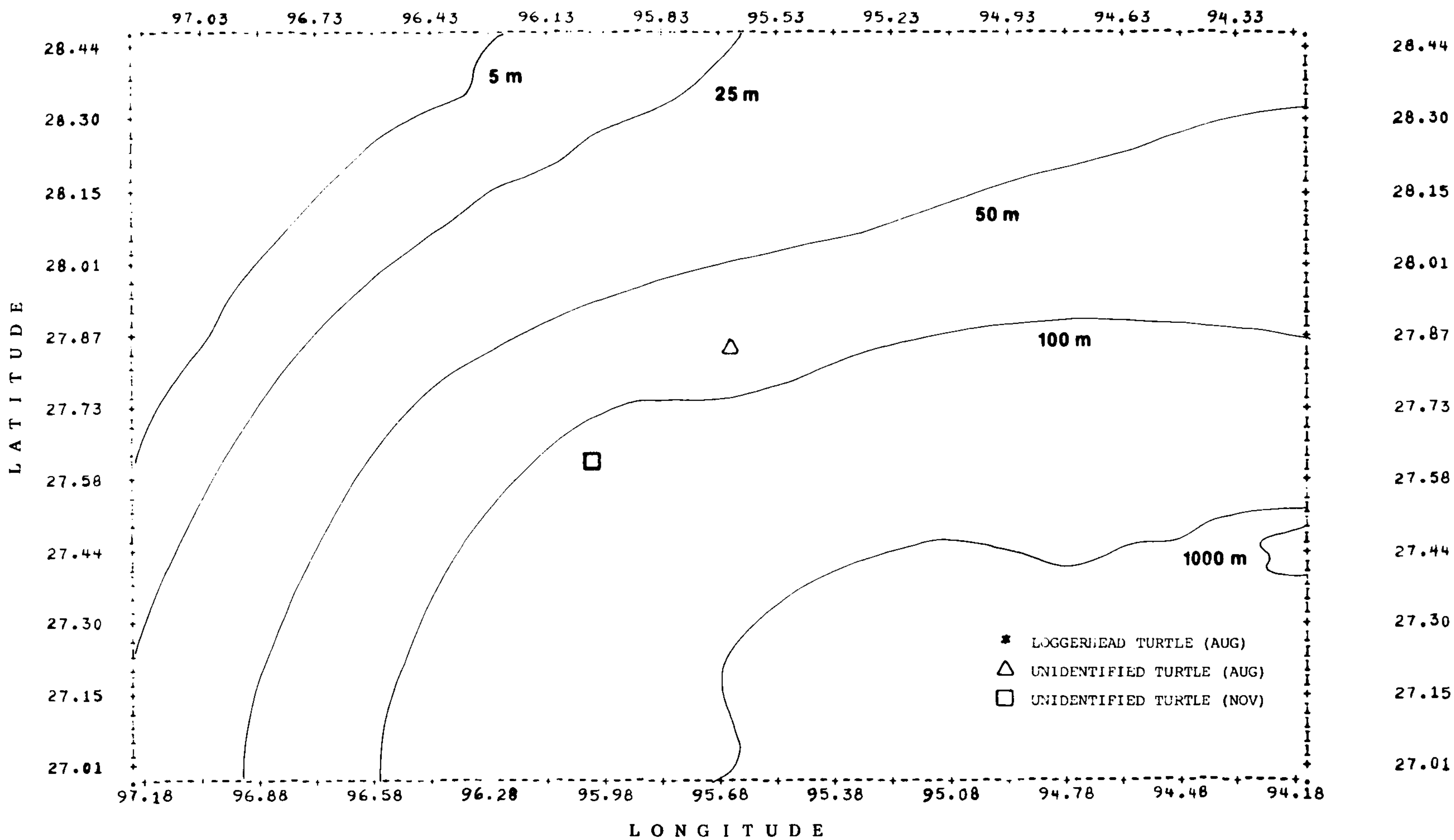
Map 50. Groups of magnificent frigatebirds sighted in SFLA during August. Numbers indicate the number of sightings at a single map point.



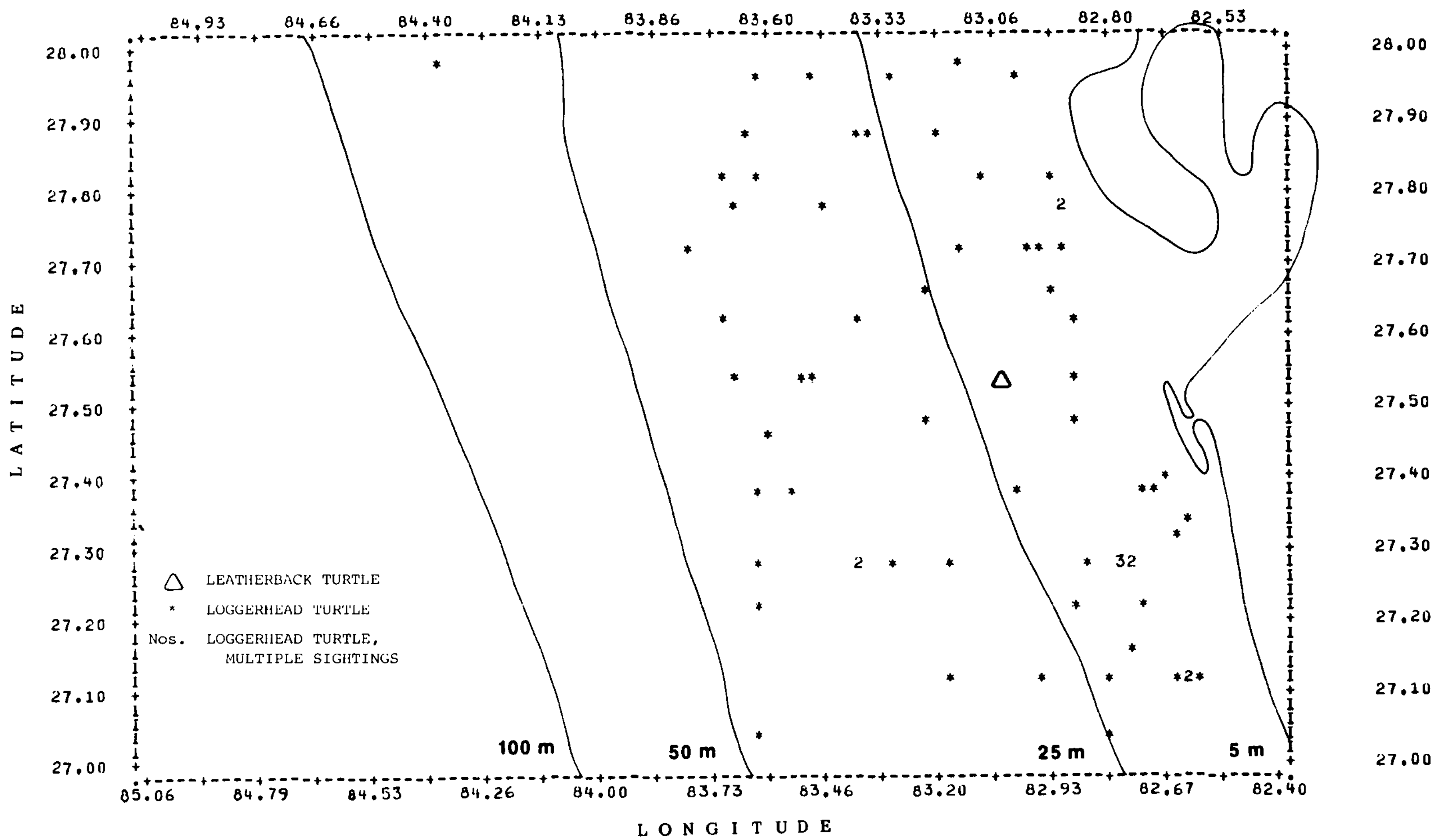
Map 51. Groups of bridled terns, sooty terns, Cory's shearwaters, and storm-petrels sighted in SFLA during August.



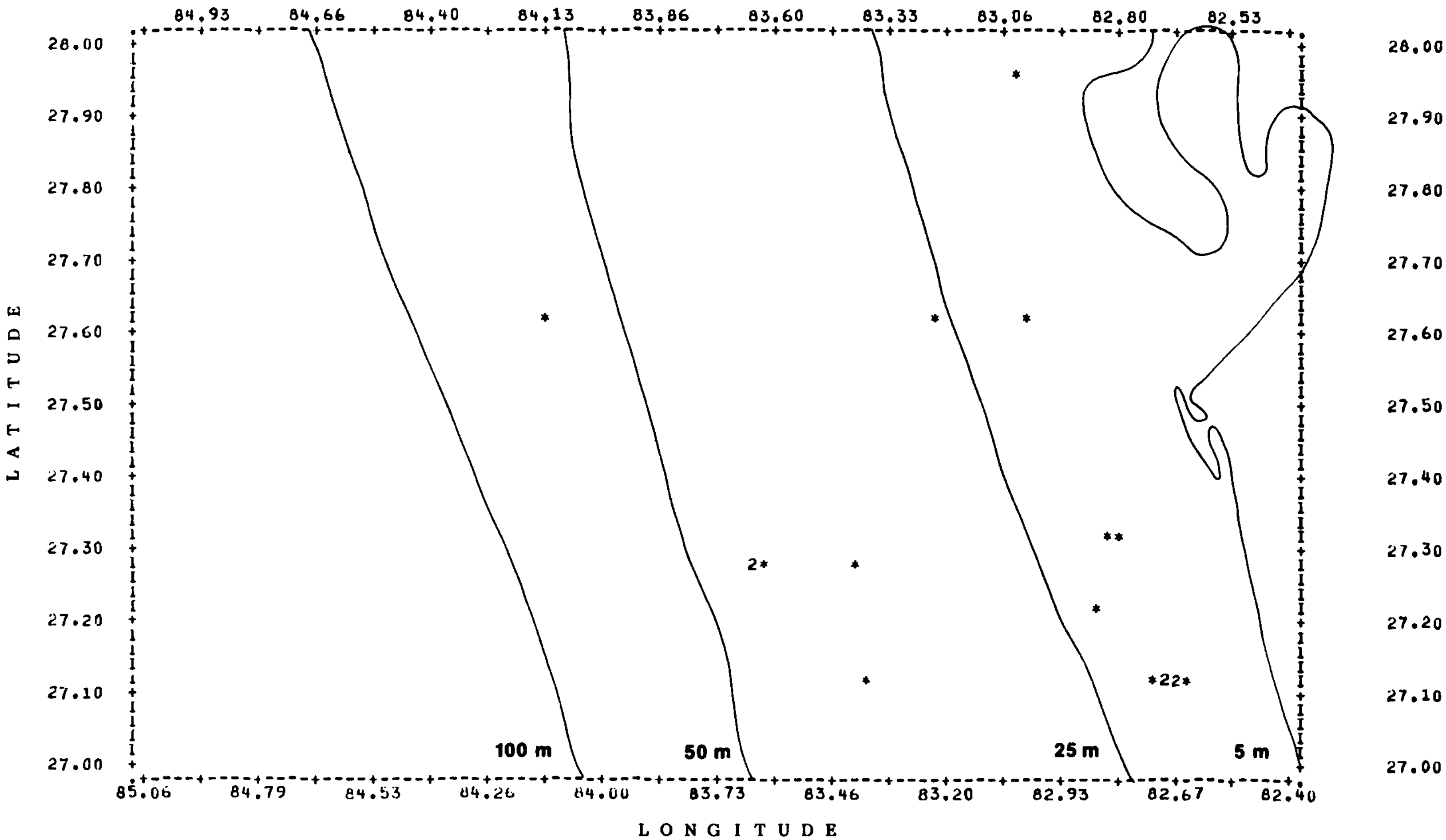
Map 52. Sightings of turtles in STEX during the Pilot Study.



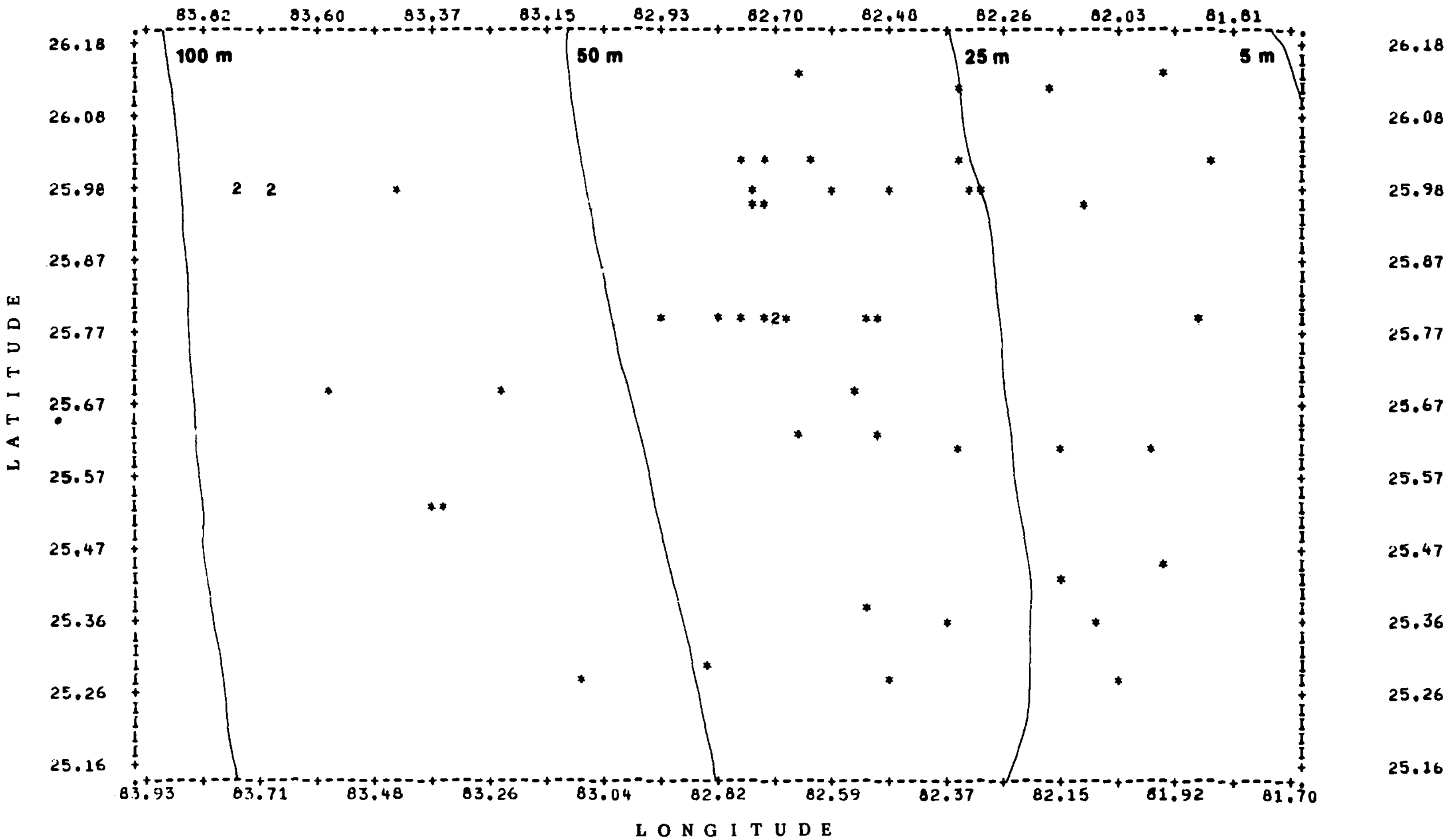
Map 53. Sightings of turtles in NTEX during the Pilot Study.



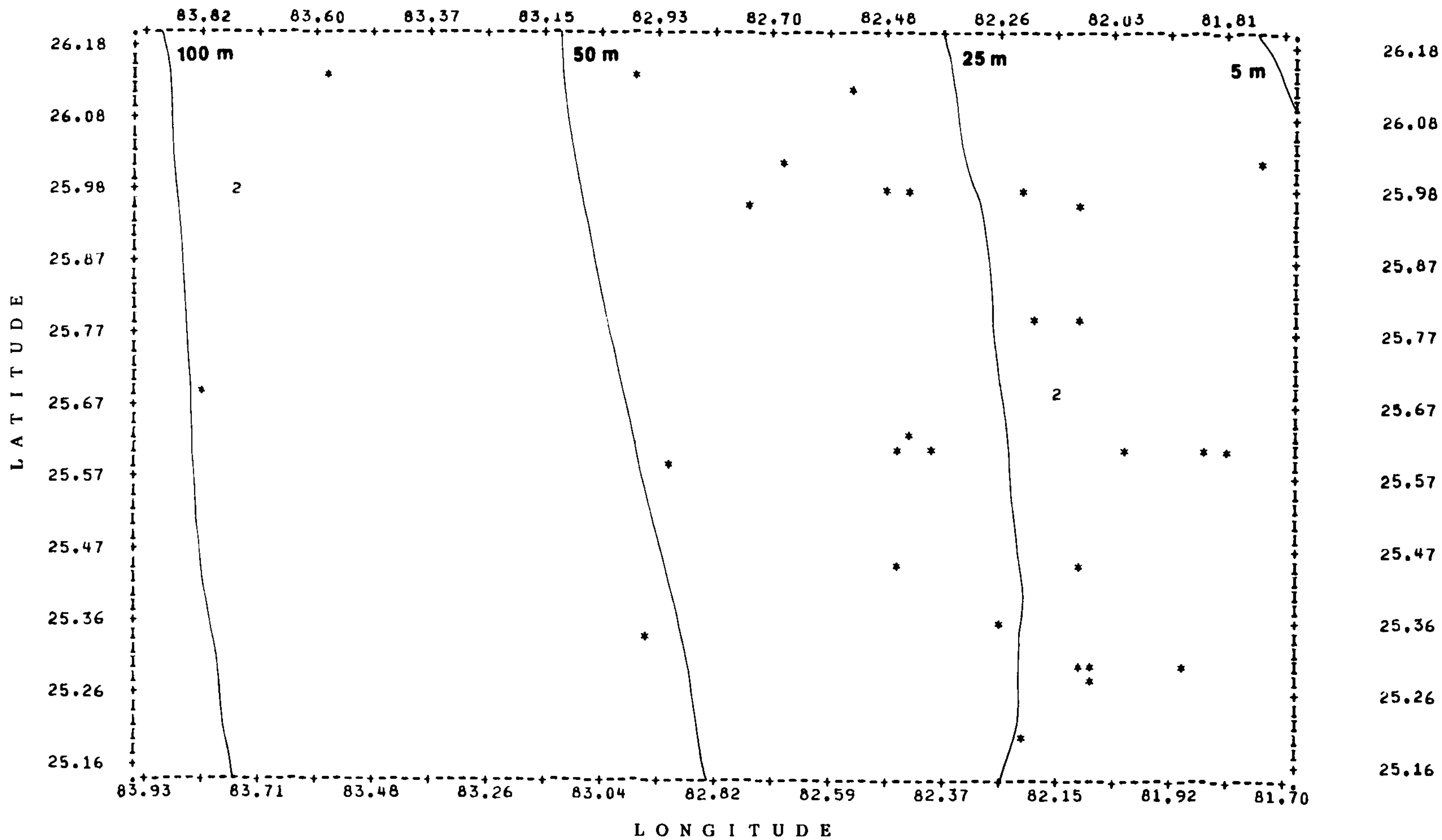
Map 54. Sightings of leatherback and loggerhead turtles in NFLA during August.



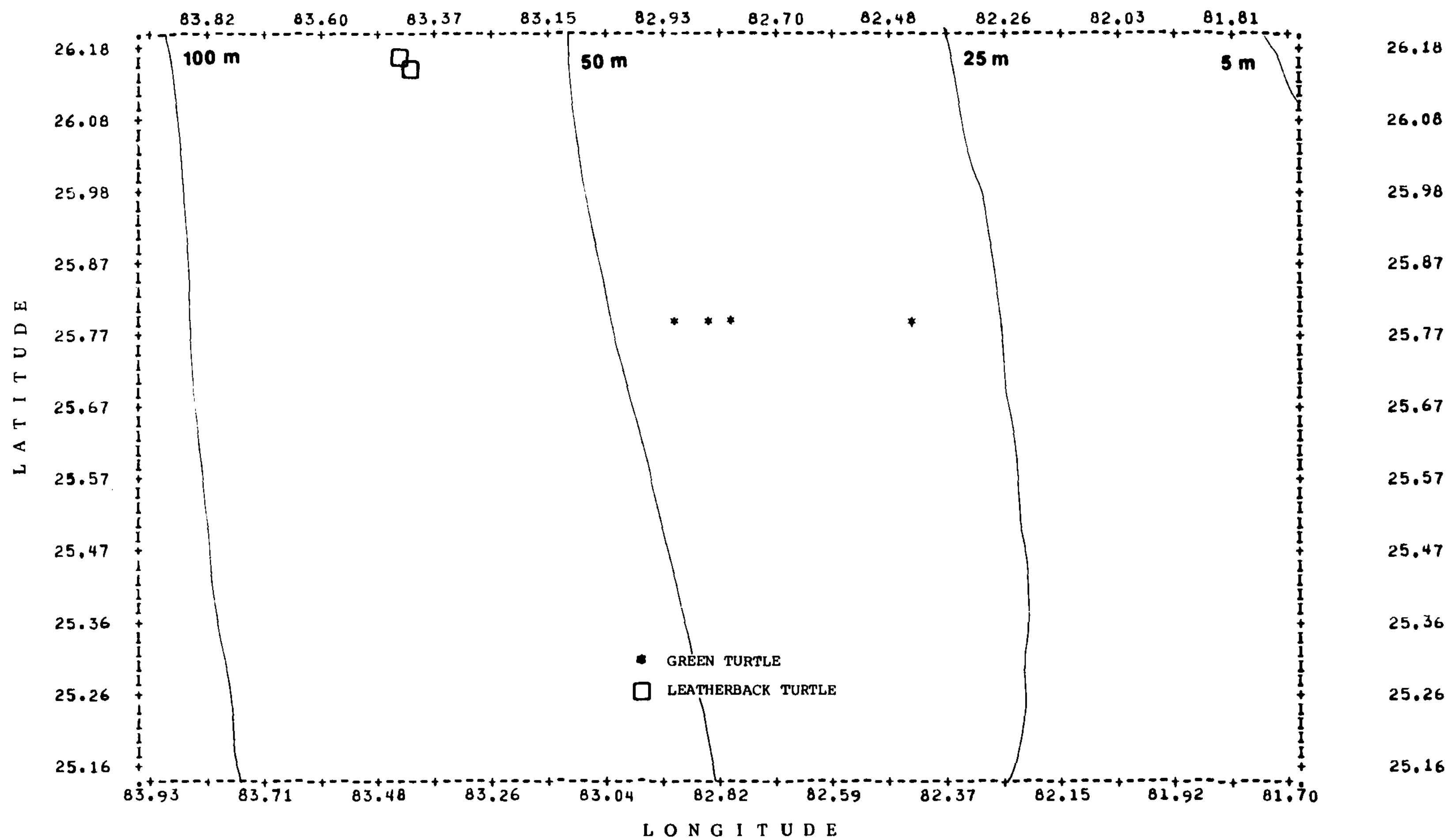
Map 55. Sightings of unidentified turtles in NFLA during August. Numbers indicate the number of sightings at a single map point.



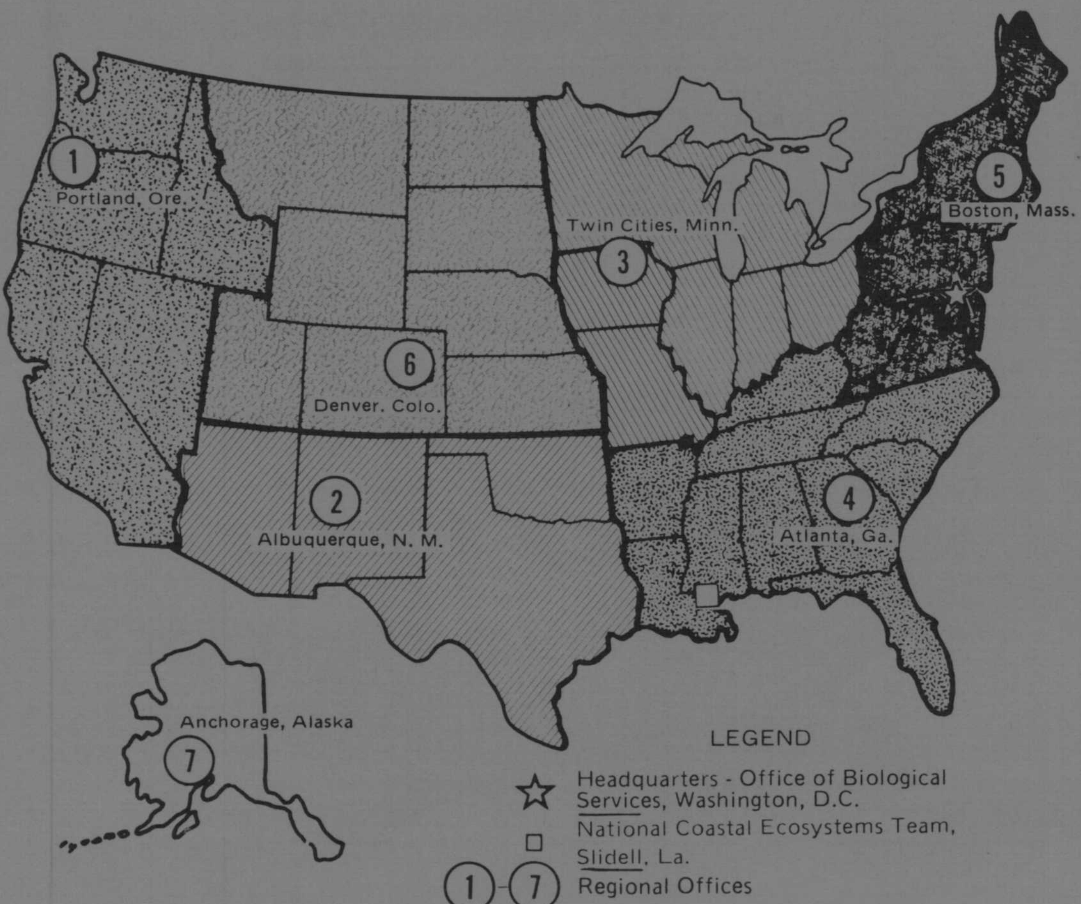
Map 56. Sightings of loggerhead turtles in SFLA during August. Numbers indicate the number of sightings at a single map point.



Map 57. Sightings of unidentified turtles in SFLA during August. Numbers indicate the number of sightings at a single map point.



Map 58. Sightings of green and leatherback turtles in SFLA during August.



U.S. FISH AND WILDLIFE SERVICE
REGIONAL OFFICES

REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.