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NOAA Technical Memorandum NMFS

SEPTEMBER 1990

SUMMARY OF THE 1988

U.S. TUNA/DOLPHIN OBSERVER DATA

Alan Jackson

NOAA-TM-NMFS-SWFC-149

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center

NOAA Technical Memorandum NMFS

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NOAA Technical Memorandum NMFS

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SUMMARY OF THE 1988 U.S. TUNA/PORPOISE OBSERVER DATA

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INTRODUCTION

Since 1971, the National Marine Fisheries Service's (NMFS) Tuna/Porpoise Observer Program has collected data on the mortality, life history, distribution and abundance of dolphins (historically referred to as "porpoise") associated with yellowfin tuna (Thunnus albacares) in the eastern tropical Pacific Ocean (ETP). This program, which became mandatory for the U.S. fleet in 1976 under the Marine Mammal Protection Act, places biological technicians (observers) aboard commercial U.S. purse seiners holding certificates of inclusion (certificated U.S. seiners) under a general permit to take (chase and/or set nets on) certain species of dolphins within the "permit area" (that area of the Pacific Ocean bounded by 40°N latitude, 40°S latitude, 160°W longitude and the coastlines of the Americas). The yellowfin tuna purse seine fishery exploits the tuna-dolphin bond by netting the highly visible, surface-swimming dolphins in an attempt to catch the tuna schooling below them. This fishing strategy is referred to by the fishermen as "porpoise fishing" or "fishing on porpoise," and, as employed by the international fleet, accounted for about 20% of the worldwide yellowfin tuna catch in 1987, or about 5% of the worldwide catch of all tunas and tuna-like species (IATTC 1989, FAO 1989). Each year, thousands of dolphins are killed in the purse seines before they can be separated from the tuna and safely returned to the open ocean.[1] Most frequently killed in this fishery are the offshore spotted dolphin (Stenella attenuata), the eastern and whitebelly spinner dolphins (S. longirostris) and the common dolphin (Delphinus delphis).

The primary responsibility of the tuna/porpoise observer is to keep an accurate count of the number, the species and the stock of dolphins killed in each purse seine set.[2] The observers are employees of NMFS, and collect data under the direction of either the NMFS's Tuna/Porpoise Management Branch or the Inter-American Tropical Tuna Commission (IATTC), an international agency concerned with the biology and conservation of tunas and associated dolphins in the ETP. Depending on the type of observed trip, whether

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[1]The estimated number of dolphins killed by the international fleet for 1988 was 84,881 (U.S. Marine Mammal Commission 1990). The annual allowable quota for certificated U.S. seiners is 20,500 dolphins.

[2]1988 Tuna/Porpoise Observer Administrative Handbook. Edited by Ben Meyer, National Marine Fisheries Service. 1520 State Street, Suite 200, San Diego, CA 92101.

directed by NMFS or IATTC, slightly different sets of data are collected.[3,4] However, dolphin mortality information is collected by all observers. Observers are also placed by IATTC on a sample of fishing trips made by foreign purse seiners. Data on these foreign trips are not included here.

This report is the second in a series of annual reports that summarize U.S. tuna/porpoise observer data collected in the ETP. Included here are dolphin set totals, mortality rates and sightings categorized by dolphin population and geographic area for the 1988 calendar year.

SAMPLING COVERAGE

All U.S. tuna purse seiners fishing on dolphins within the permit area are required to carry observers on some or all of their fishing trips, based on a sampling scheme designed to provide a reliable estimate of the total dolphin mortality attributable to the entire certificated U.S. fleet (Lo et al. 1982). In 1988, certificated U.S. purse seiners made 148 fishing trips entirely or partially within the calendar year, for a total of 7,882 fleet days.[5] U.S. observers were aboard 81 of these trips for a total of 4,173 days and an overall observer coverage rate of 54.7% of trips and 52.9% of fleet days. Of the 37 certificated U.S. seiners active in the ETP in 1988, 36 carried an observer on at least one trip; 1 seiner, making its maiden voyage in late 1988, went unobserved. The average length of an observed trip (excluding transit time outside the permit area and unloading time) was 58 days, shorter by 11 days than the average of 69 days for 1987. Trips in 1988 ranged from 25 to 110 days in duration (Table 1). There was very little difference, on average, in trip lengths throughout the year.

There were 37 certificated U.S. purse seiners active in the ETP in 1988 (up from the 1987 total of 34), but by year's end, the number of active vessels stood at 31. Ten vessels left the U.S. fleet in 1988: 8 vessels were sold to foreign concerns (5 to South Korea, and 1 each to France, Vanuatu and Venezuela) and 2 vessels left the ETP for fishing grounds in the western Pacific. There was, however, the addition of 4 vessels to the fleet: 2 vessels that did not fish at all in 1987 were reactivated; 1 vessel entered

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[3]1988 Tuna/Porpoise Observer Field Manual. National Marine Fisheries Service. 1520 State Street, Suite 200, San Diego, CA 92101.

[4]1988 Inter-American Tropical Tuna Commission Tuna-Dolphin Investigation Field Manual. Edited by David Bratten, Inter-American Tropical Tuna Commission. c/o Scripps Institution of Oceanography, La Jolla, CA 92093.

[5]Ben Meyer, National Marine Fisheries Service, 1520 State Street, Suite 200, San Diego, CA 92101, pers. commun. July 1990.

the ETP from the western Pacific; and 1 newly built vessel began fishing.

DOLPHIN SETS

The 148 trips observed in 1988 resulted in 1,958 intentional dolphin sets (setting the net in an attempt to capture dolphins) with a total catch of 33,898 short tons of yellowfin tuna[6] (catch estimated at sea--Table 2). The average observed yellowfin tuna catch-per-set on a school of dolphins was 17.3 short tons, identical to the 1987 observed catch-per-set rate and practically unchanged from the 1983-87 rate of 17.6 short tons. The average observed yellowfin tuna catch-per-set on a school of dolphins for 1976 to 1988 is given in Figure 1. In addition to the 1,958 intentional dolphin sets, 3 accidental dolphin sets (sets in which dolphins were captured merely by chance or without intention) and 1 set on a whale were reported for 1988.

The geographic patterns of fishing on dolphins in 1988 differed somewhat from those of 1987 (Jackson 1989). In general, sets were dispersed over a wider area, and fishing effort was less concentrated between 10-15°N and 95-110°W, an area that has traditionally been the center of dolphin fishing. The observed fleet ventured farther west than in 1987, setting on dolphins west of 140°W, and farther south, with some dolphin fishing occurring in an area centered at about 10°S and 85°W (Figure 2A).

Dolphin fishing areas tended to change over the course of the 1988 calendar year, generally reflecting a pattern that has become established over the past ten years (IATTC 1985). As in 1987, activity for the first quarter of the year was generally confined to an area within 500-600 miles of the coastline between 5-18°N, with a concentration of sets centered at about 12°N and 90°W (Figure 2B). Unlike 1987, however, but not unusual for the first quarter of the year, there was some dolphin fishing in the southern area centered at about 10°S and 85°W. Another change from 1987 was an area of dolphin fishing (primarily involving common dolphins) off Costa Rica. Fishing effort shifted westward in the second quarter (Figure 2C). During the third quarter, most dolphin fishing activity moved eastward to an area centered at 10°N and 100°W, although there was some activity as far west as 140°W (Figure 2D). There was a return to nearer-shore area in the fourth quarter (Figure 2E).

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[6]Although yellowfin tuna is the expected catch in dolphin sets, skipjack tuna (Katsuwonus pelamis) is also occasionally caught in these sets. In 1988, a total of 1,360 short tons of skipjack tuna were caught in the 1,958 observed intentional dolphin sets.

DOLPHIN MORTALITY

A total of 10,200 dolphins[7] were killed in observed U.S. tuna purse seine trips in 1988 (Table 3). These dolphins were all killed in intentional dolphin sets--there were no mortalities resulting from accidental dolphin sets. The offshore spotted dolphin population sustained the most mortalities (4,967), followed by the whitebelly spinner dolphin (1,791), the eastern spinner dolphin (1,457) and the common dolphin (1,413). The geographic distributions of the total observed dolphin mortality, by population, are depicted in Figures 3A-E.

Because dolphins from different populations (especially spotted and spinner dolphins) often school together and, consequently, are often netted together, determining dolphin mortality rates (kill-per-set and kill-per-ton) by dolphin population is problematical. For this report, the following methods were used: The overall dolphin kill-per-set and kill-per-ton rates are the total number of dolphins (of all populations) killed in intentional dolphin sets, 1) divided by the total number of intentional dolphin sets; or 2) divided by the total number of short tons of yellowfin tuna caught (estimated at sea) from intentional dolphin sets. Intentional dolphin sets include sets in which no dolphins were successfully captured. For mortality rates by specific dolphin populations, a set is included for a population only if the dolphin school that was chased and set upon contained individuals of that population (observer's determination; recorded on the sighting record as one percent, or more, of the entire school); no attempt was made to allocate or proportion the tuna catch between populations if more than one dolphin population was involved in the set. Examples of these methods are given by Jackson (1989).

The dolphin most frequently set on by observed U.S. seiners in 1988 was the offshore spotted dolphin (1,850 intentional sets), resulting in average kill-per-set and kill-per-ton of yellowfin tuna rates of 2.68 and 0.15 dolphins (Table 4). This was followed by the eastern spinner (630 sets), with rates of 2.31 and 0.12, and the whitebelly spinner (328 sets), with rates of 5.46 and 0.24.

The 1988 overall dolphin kill-per-set and kill-per-ton rates of 5.21 and 0.30 were higher than the 1987 rates of 3.11 and 0.18 and the 1983-87 average rates of 4.26 and 0.24. Some of the factors contributing to the higher kill rates were: higher proportion of sets on common dolphins in 1988 (8.4%) than in 1987 (4.4%); lower proportion of dolphin sets in an area (east of 132°W and north of 5°N) historically characterized by lower kill rates in 1988 (76.1%) than in 1987 (92.3%); lower proportion of no-kill sets in 1988 (55.0%) than in 1987 (61.9); and higher proportion of very

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[7]The estimated number of dolphins killed by the entire certificated U.S. fleet, including unobserved fishing trips, for 1988 was 19,712, based on the 10,200 observed mortalities and the observer coverage rate (U.S. Marine Mammal Commission 1990).

high kill sets (more than 50 dolphins killed) in 1988 (1.7%) than in 1987 (0.8%). After tremendous improvements in dolphin kill-per-set and kill-per-ton rates in 1977, the performance of the U.S. fleet has remained relatively constant over the past 12 years (Figures 4A,B).

Of the 1,958 intentional dolphin sets, 1,077 sets (or 55.0% of the total) resulted in no dolphin mortality, and 136 (6.9% of the total) were sets in which more than 15 dolphins were killed (Figure 5A). This compares poorly to 1987 when no-kill sets accounted for 61.9% of the total and >15-kill sets accounted for 4.3%, and to the 1983-87 average rates of 60.2% and 5.4%. Over 70% of the dolphin mortality in 1988 occurred in >15-kill sets (Figure 5B). The greatest number of dolphins killed in a single set in 1988 was 567 (524 whitebelly spinner and 43 offshore spotted dolphins).

The relative frequencies of numbers of dolphins killed per set were quite similar for the three most frequently set upon populations: offshore spotted, eastern spinner and whitebelly spinner dolphins. For the common dolphin, however, there is a pronounced shift to the high end in the kill-per-set frequencies, with >15-kill sets accounting for 25.3% of the total (Figure 6).

Common dolphin kill rates have tended to be much higher than those for the other dolphins involved in the fishery. The 1983-87 average kill-per-set and kill-per-ton rates for common dolphins are 20.6 and 1.65, compared to rates of 3.87 and 0.22 on other dolphins. From 1979 to 1988, 2.8% of all observed dolphin sets were on common dolphins. These sets accounted for 8.3% of all observed dolphin mortalities, while the amount of yellowfin tuna caught in these sets represents only 1.9% of the amount of tuna caught in all observed dolphin sets for this period. In 1988, 1,413 common dolphins were killed in a total of only 87 intentional sets involving this species, with resulting kill-per-set and kill-per-ton rates of 16.2 and 1.13, compared to rates of 4.70 and 0.27 for sets on other dolphins. The 1988 common dolphin mortality rates were affected by a single set that resulted in a kill of 229 common dolphins and a tuna catch of 12 tons. Even when this one set is removed, the common dolphin kill-per-set and kill-per-ton rates (13.8 and 0.96) are still high.

Although dolphins can only practicably be herded and set upon during daylight hours, sometimes, especially for sets that are started shortly before or at sunset, dolphins may remain in the net until after nightfall. These "sundown sets" present unique problems to the safe release of the dolphins from the net.[8] In 1988, 8.4% of intentional dolphin sets were sundown sets, with resulting kill-per-set and kill-per-ton rates of 14.0 and 0.76,

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[8]As of January 1, 1989, U.S. tuna fishermen are required to complete the process of backdown to remove dolphins from the net no later than 30 minutes after sundown (Marine Mammal Protection Act Amendments of 1988).

versus 4.51 and 0.26 for daylight sets (Figures 7A,B). For 1987, 10.2% of all intentional dolphin sets were sundown sets, with resulting average kill-per-set and kill-per-ton rates of 7.88 and 0.46, versus 2.57 and 0.15 for daylight sets. During the period 1983-87, 10.5% were sundown sets, with kill rates of 13.44 and 0.71, versus 3.02 and 0.17 for daylight sets.[9]

Geographically, areas of high dolphin kill-per-set and kill-per-ton in 1988 tended to be located along the southern and western periphery of the general fishing area, areas that historically have not been heavily fished, and off Costa Rica (Figures 8A,B). This situation is consistent with that of previous years (IATTC 1989). The dolphin most often involved in high-kill sets along the southern and western periphery was the offshore spotted dolphin; the high-kill sets off of Costa Rica involved the common dolphin, almost exclusively.

MARINE MAMMAL WATCH EFFORT AND SIGHTINGS

Marine mammal watch effort is an activity in which the observer keeps a lookout for marine mammals, or is otherwise in a position to note marine mammal sightings made by the seiner's crew. During periods of watch effort, various conditions are monitored and recorded, including vessel speed and position, sea surface temperature and sea state.

In 1988, U.S. observers logged 18,063 hours of watch effort, during which 349,755 kilometers of distance were traveled. There were 2,558 sightings reported by observers of offshore spotted dolphins, the population normally sought by the fishery, with an estimated average school size of 610 dolphins (Table 5). Also frequently sighted, and often in association with spotted dolphins, were eastern spinner dolphins (903 sightings, average school size of 413) and whitebelly spinner dolphins (425 sightings, average school size of 254). Other cetaceans quite frequently encountered, yet not normally associated with yellowfin tuna, were bottlenose dolphins (383 sightings), short-finned pilot whales (Globicephala macrorhynchus, 203 sightings) and sperm whales (Physeter macrocephalus, 126 sightings). Locations of dolphin sightings, by population, are depicted in Figures 9A-D. Because of the broad overlap of the ranges of eastern and whitebelly spinner dolphins, and because of problems observers have in distinguishing between these two forms at sea, the distribution data for whitebelly and eastern spinner dolphins should be regarded as less reliable than the data for spotted and common dolphins (Perrin et al. 1985).

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[9]Coan, A.L., K.E. Wallace and A.R. Jackson. 1988. Comparisons of dolphin mortality rates between day and night sets for the U.S. eastern tropical Pacific tuna purse seine fishery. Southwest Fisheries Center Admin. Rep. LJ-88-29, 24 p.

DOLPHIN LIFE HISTORY SPECIMENS

Under certain conditions, the observer has access to dolphin carcasses and can collect data, organs and tissues for later analysis at the Southwest Fisheries Science Center. The minimum amount of data recorded for each processed specimen includes species identification, sex, date, position of capture and body length. A more complete record includes, in addition to data collected at sea, information obtained from the laboratory examination of the teeth, fetuses and testes or ovaries collected in the field.

Complete life history data were collected for 1,512 dolphins, or 15% of the animals that were observed to be taken in the fishery in 1988; minimum data were collected for an additional 369 dolphins (Table 6).

SUMMARY

In 1988, 81 of the 148 fishing trips made entirely or partially within the calendar year by U.S. tuna purse seiners to the permit area carried observers. On these 81 observed trips, 1,958 intentional dolphin sets were made, resulting in a yellowfin tuna catch of 33,898 short tons and 10,200 dolphins killed. The observed dolphin kill-per-set and kill-per-ton of yellowfin tuna rates were 5.21 and 0.30 dolphins, higher than the 1987 rates of 3.11 and 0.18 dolphins and the 1983-87 average rates of 4.26 and 0.24. Over 70% of the dolphin mortality in 1988 occurred in sets in which more than 15 dolphins were killed. As in 1987, the 1988 kill-per-set and kill-per-ton rates for common dolphins were found to be much higher than for the other dolphins, although there were only 36 observed sets on common dolphins in 1987 and 87 sets in 1988. Of all 1,958 intentional dolphin sets, 8.4% were sundown sets, with resulting kill-per-set and kill-per-ton rates of 14.0 and 0.76. These sundown set kill rates were higher than the 1987 sundown set averages of 7.88 and 0.46 dolphins, but practically unchanged from the 1983-87 average rates of 13.44 and 0.71. Geographic areas of high dolphin kill-per-set and kill-per-ton tended to be located along the southern and western periphery of the traditional fishing grounds and off Costa Rica.

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I wish to acknowledge the efforts and perseverance of the observers who spent many long months at sea collecting the data summarized in this report; theirs is a difficult and, too often, thankless job. I also wish to acknowledge R. Rasmussen and M. Trianni who edited the NMFS data. My thanks go to the IATTC for providing the data collected by their observers and to S. Boyer for extracting the IATTC data I required. R. Allen enhanced the appearance of the figures. J. Barlow, A. Coan, M. Hall, R. McInnis, R. Salomons, S. Smith and K. Wallace reviewed this manuscript and offered useful suggestions for its improvement. I thank these people and others who helped me.

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U.S. Marine Mammal Commission. 1990. Annual Report of the Marine Mammal Commission, Calendar Year 1989, a Report to Congress. U.S. Marine Mammal Commission, 1625 I Street, N.W., Washington, D.C., 20006.

Table 1. Trip lengths, in days, of observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean, 1988.

	Observed Trip Lengths (Days) .....Trips Departing..... Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total
Average trip length	58	58	57	63	58
Maximum trip length	98	91	88	110	110
Minimum trip length	37	25	32	38	25
Number of departures	14	20	18	10	62

(This table excludes 19 cruises that departed in 1987 and continued fishing into 1988.)

Table 2. Sets on marine mammals from observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean, 1988.

	Number Sets	Tons Yellowfin	Tons Skipjack
Intentional dolphin	1,958	33,898	1,360
Accidental dolphin	3	0	10
Whale	1	4	80
-Total-	1,962	33,902	1,450

Table 3. The dolphin mortality from observed U.S. tuna purse seine trips, and the NMFS-estimated mortality attributable to the entire U.S. certificated fleet in the eastern tropical Pacific Ocean, 1988.

Population	Observed Mortality				Estimated Mortality[1]
	Male	Female	?-Sex	Total	
Offshore spotted	942	1,178	2,847	4,967	9,511
Whitebelly spinner	312	325	1,154	1,791	3,516
Eastern spinner	288	287	882	1,457	2,832
Common	209	189	1,015	1,413	2,790
Costa Rican spinner	35	37	289	361	*
Unidentified	0	0	106	106	*
Striped	22	2	17	41	81
Unidentified spinner	7	9	17	33	*
Fraser's	3	2	10	15	*
Bottlenose	2	6	2	10	*
Rough-toothed	2	1	3	6	*
-Total-	1,822	2,036	6,342	10,200	19,712

[1]Porpoise Mortality Status Report No. 88-29. National Marine Fisheries Service. 1520 State Street, Suite 200, San Diego, CA 92101.
*No estimation was made for this category.

Table 4. Dolphin kill-per-set and kill-per-ton of yellowfin tuna resulting from intentional dolphin sets made on observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean, 1988.

Population	Sets	Kill	Tons	Kill /Set	Kill /Ton
Offshore spotted	1,850	4,967	32,366	2.68	0.15
Eastern spinner	630	1,457	11,812	2.31	0.12
Whitebelly spinner	328	1,791	7,469	5.46	0.24
Common	87	1,413	1,246	16.24	1.13
-All Dolphin Sets-	1,958	10,200	33,898	5.21	0.30

(Totals do not necessarily equal the sum of the values for each column due to the fact that dolphins from more than one population may be present in a given set, and totals include unidentified dolphins and other populations.)

Table 5. Marine mammal sightings made by observers aboard U.S. tuna purse seiners in the eastern tropical Pacific Ocean, 1988.

Population	Sightings	Average School Size
Offshore spotted dolphin	2,558	610
Eastern spinner dolphin	903	413
Whitebelly spinner dolphin	425	254
Bottlenose dolphin	383	42
Common dolphin	333	892
Short-finned pilot whale	203	20
Unidentified spinner dolphin	177	218
Offshore common dolphin	151	836
Sperm whale	126	7
Striped dolphin	76	110
Risso's dolphin	41	41
Unidentified rorqual	29	6
Killer whale	26	6
Unidentified beaked whale	20	4
Coastal spotted dolphin	18	118
Fraser's dolphin	17	665
Unidentified spotted dolphin	16	294
Rough-toothed dolphin	13	10
Gray whale	12	7
False killer whale	11	13
Humpback whale	11	8
Blue whale	8	1
Pacific white-sided dolphin	6	33
Costa Rican spinner dolphin	5	3,249
Unidentified mesoplodon	3	2
Minke whale	2	2
Bryde's whale	2	2
Melon-headed whale	1	1,000
Cuvier's beaked whale	1	3

Table 6. Dolphin life history specimens collected from U.S. tuna purse seiners in the eastern tropical Pacific Ocean, 1988.

Population	Complete Data Specimens Collected Male	Female	Total	Minimum Data Specimens Collected Male	Female	Total
Offshore spotted	358	464	822	442	574	1,016
Eastern spinner	126	148	274	152	180	332
Whitebelly spinner	99	95	194	134	131	265
Common	96	64	160	116	80	196
Costa Rican spinner	23	20	43	27	23	50
Striped	10	0	10	11	0	11
Spinner, stock unknown	5	1	6	5	1	6
Rough-toothed	1	0	1	2	1	3
Bottlenose	1	0	1	1	0	1
Unidentified	1	0	1	1	0	1
-Total-	720	792	1,512	891	990	1,891

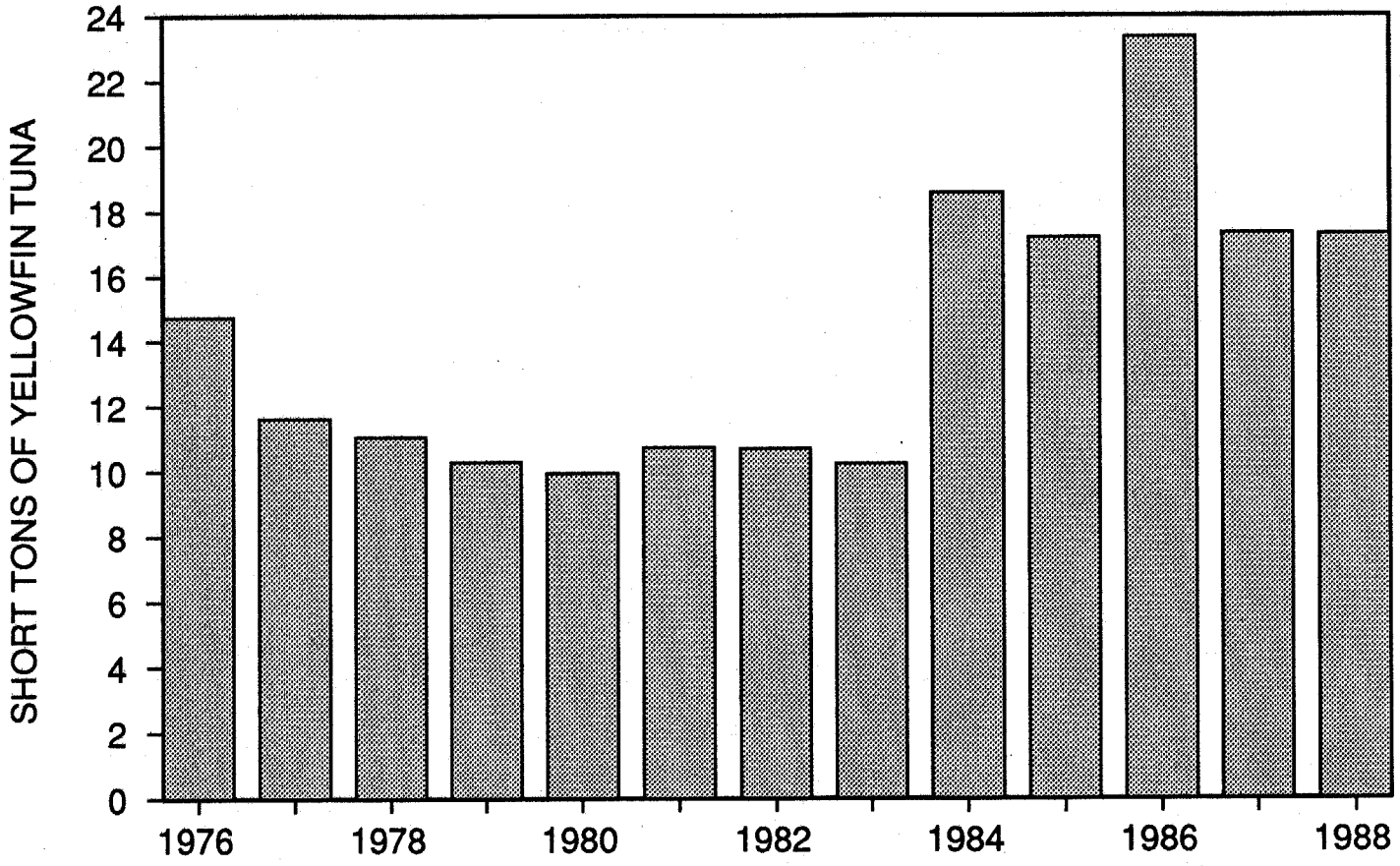

Figure 1. The average catch of yellowfin tuna per observed set on dolphins by U.S. tuna purse seiners in the eastern tropical Pacific Ocean, by year, for 1976 to 1988.

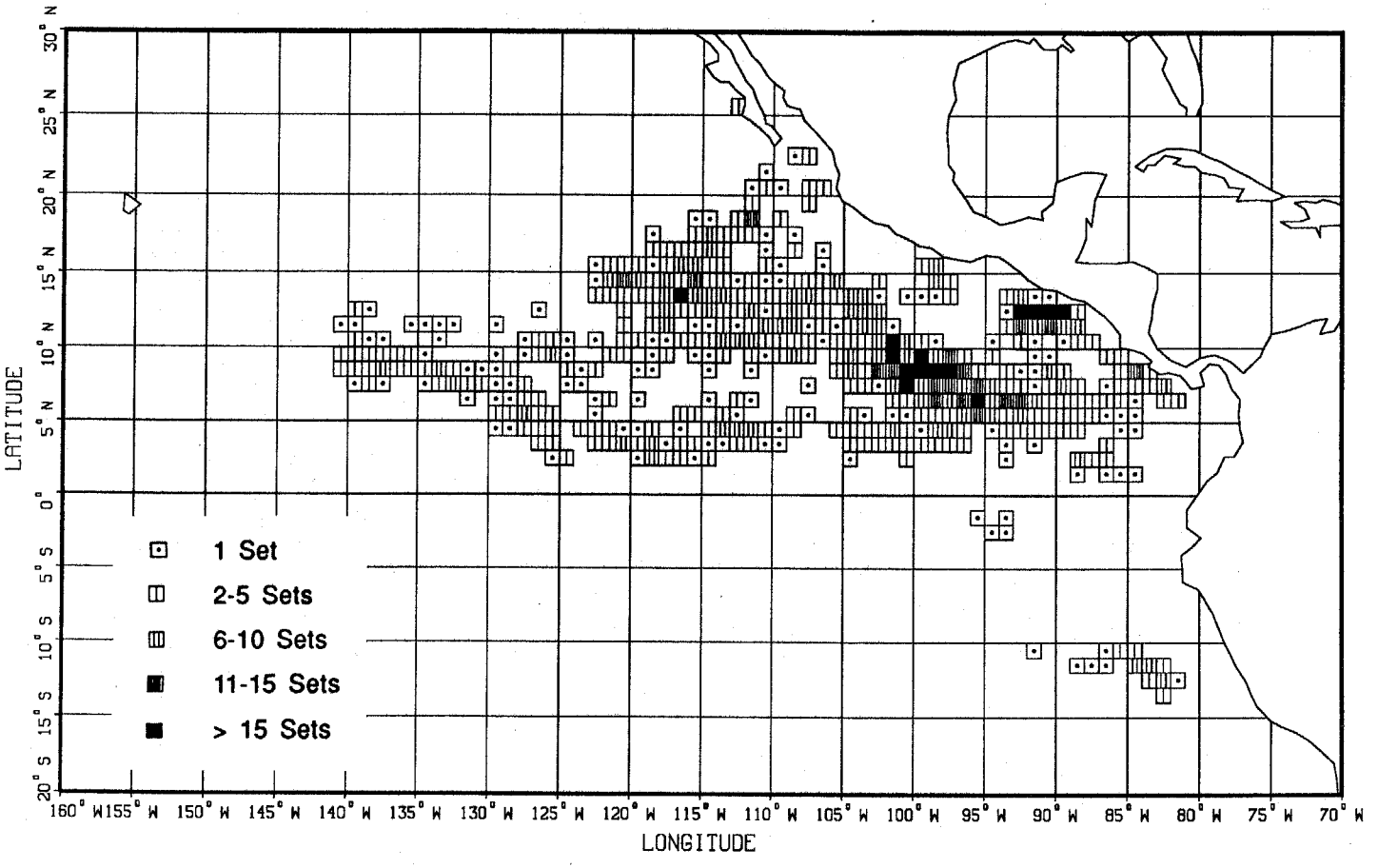

Figure 2A. The number of intentional dolphin sets, by 1^{o} quadrats, made on observed U.S. tuna purse seine trips in 1988.

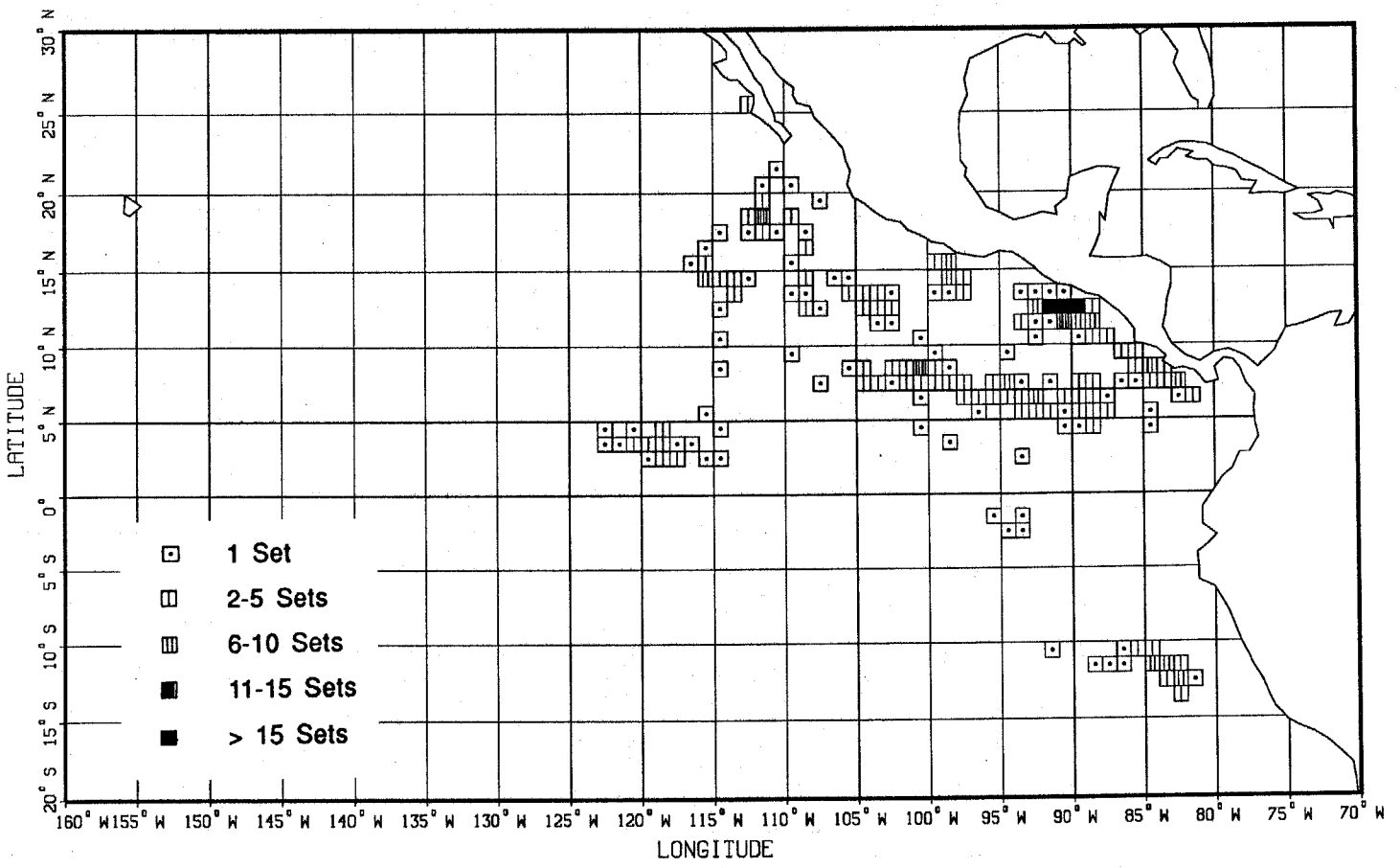

Figure 2B. The number of intentional dolphin sets, by 1^{o} quadrats, made on observed U.S. tuna purse seine trips in the first quarter of 1988.

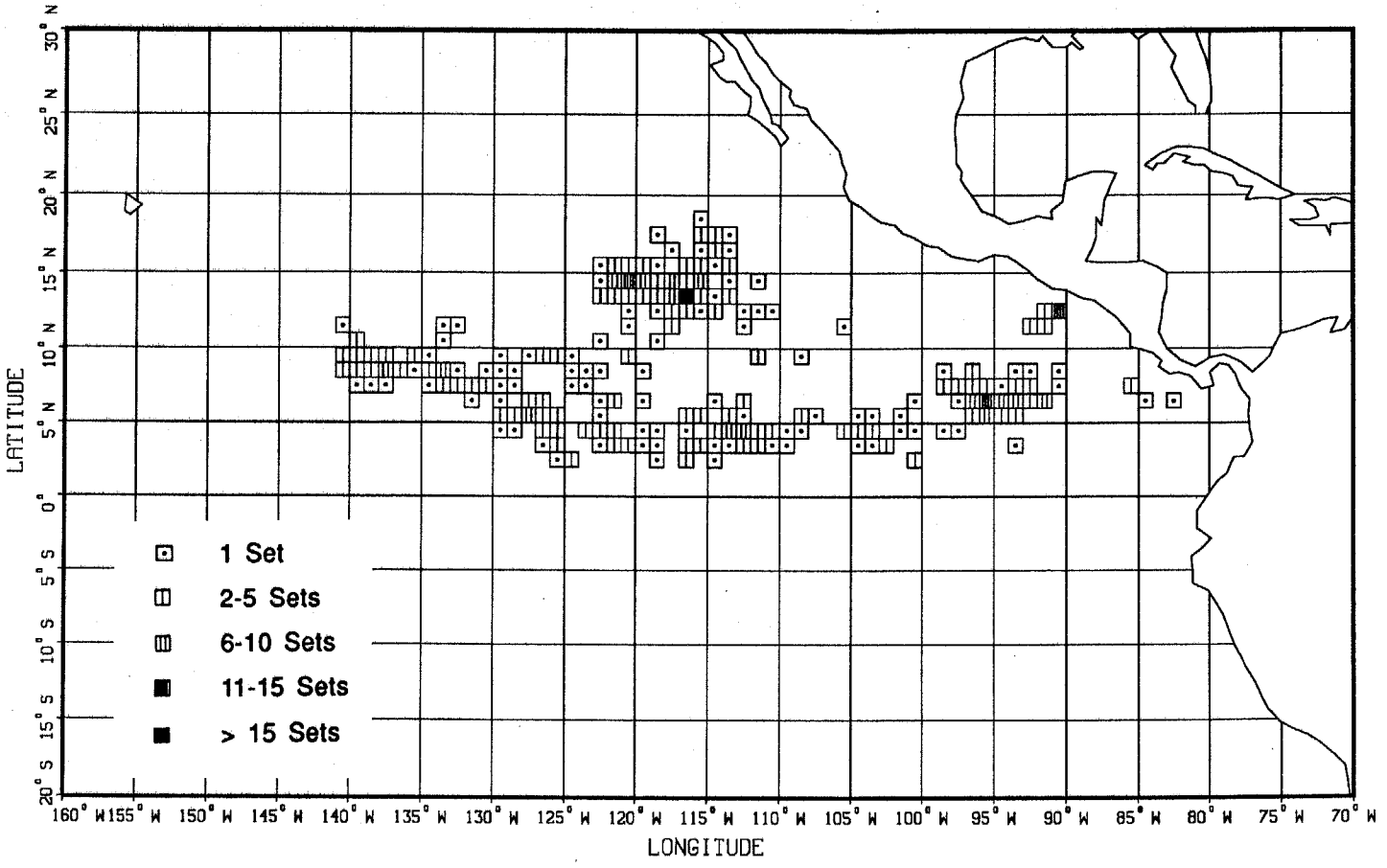

Figure 2C. The number of intentional dolphin sets, by 1^{o} quadrats, made on observed U.S. tuna purse seine trips in the second quarter of 1988.

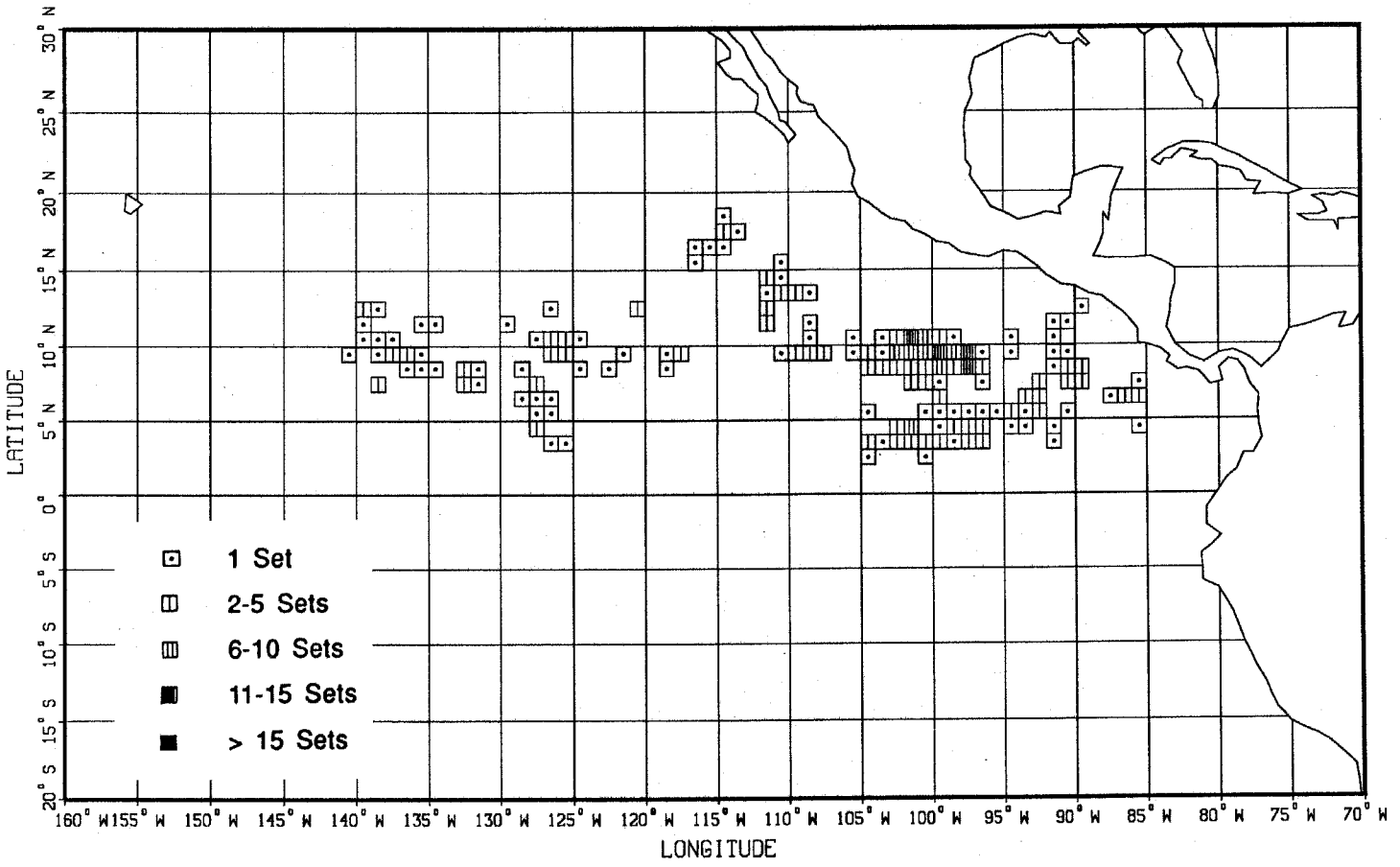

Figure 2D. The number of intentional dolphin sets, by 1^{o} quadrats, made on observed U.S. tuna purse seine trips in the third quarter of 1988.

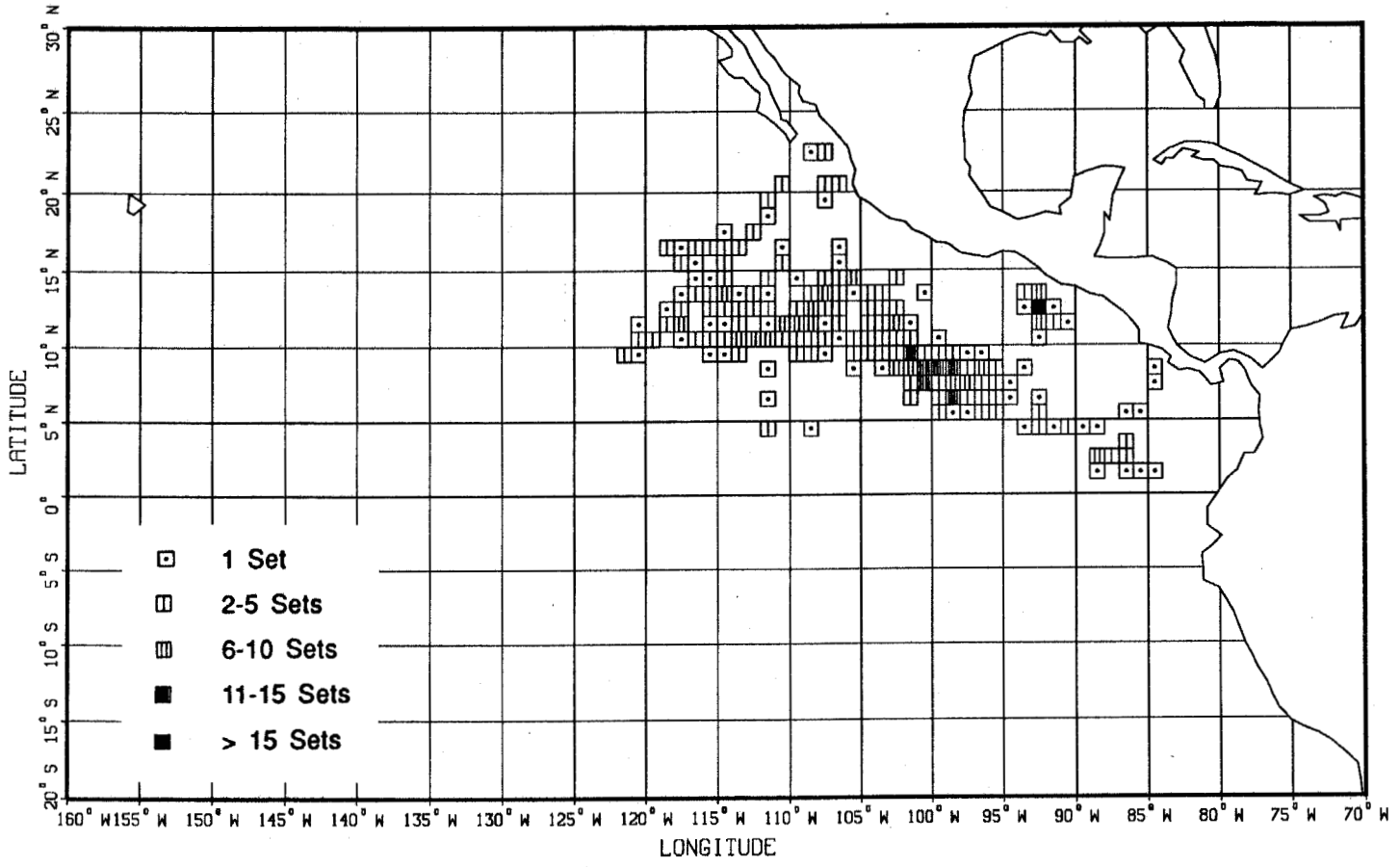

Figure 2E. The number of intentional dolphin sets, by 1^{o} quadrats, made on observed U.S. tuna purse seine trips in the fourth quarter of 1988.

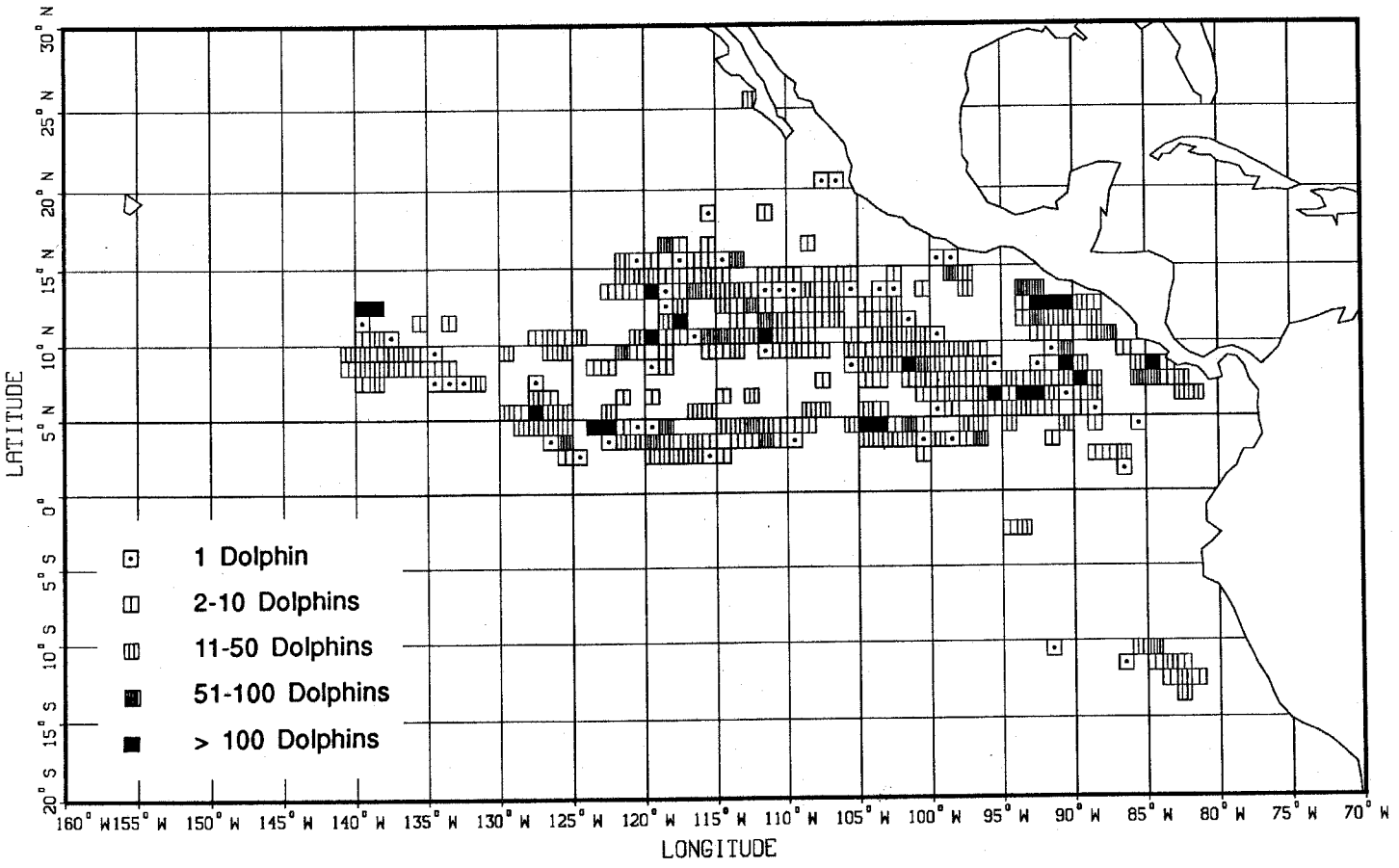

Figure 3A. The total number of dolphins, by 1^{o} quadrats, killed on observed U.S. tuna purse seine trips in 1988.

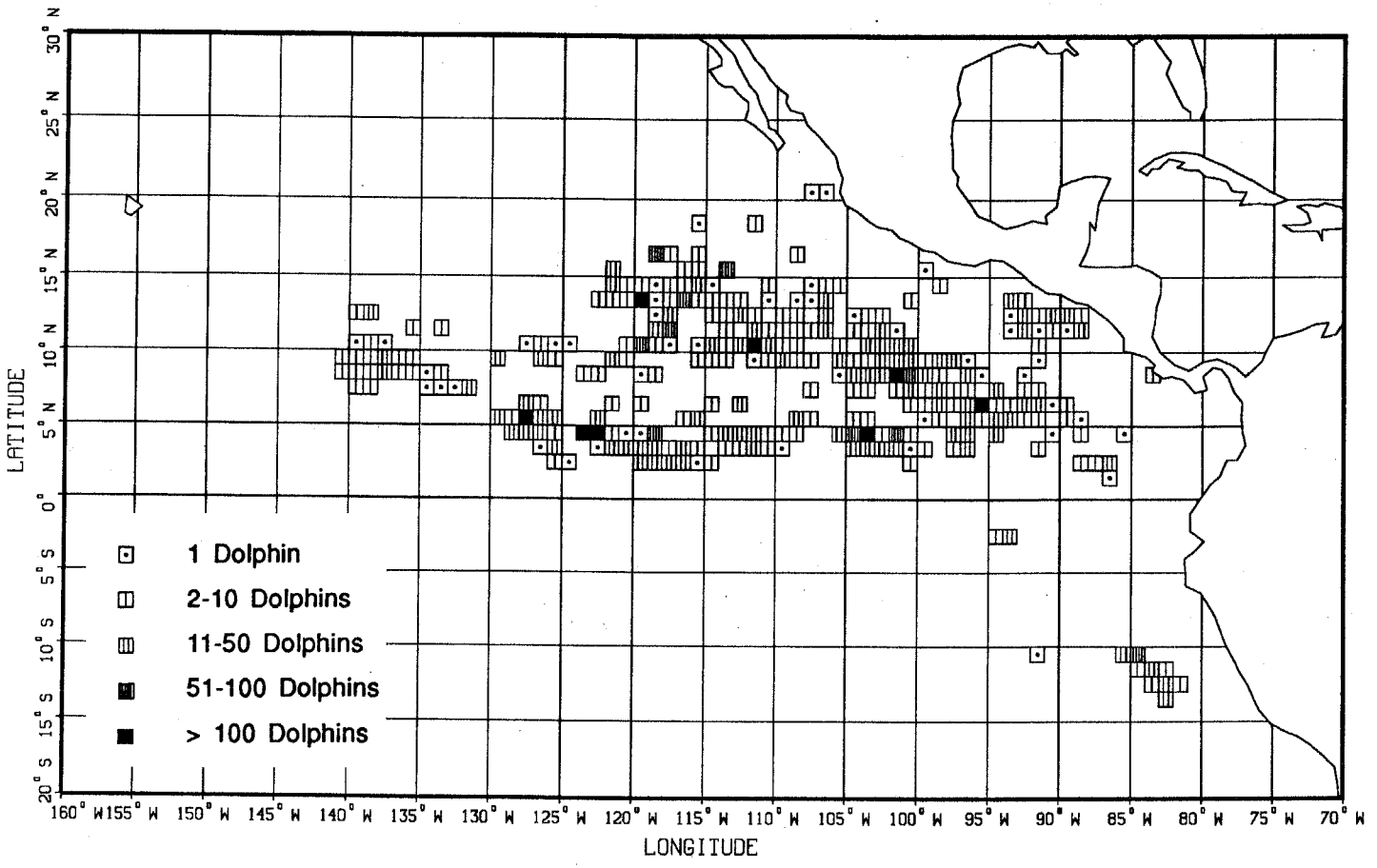

Figure 3B. The total number of offshore spotted dolphins, by 1^{o} quadrats, killed on observed U.S. tuna purse seine trips in 1988.

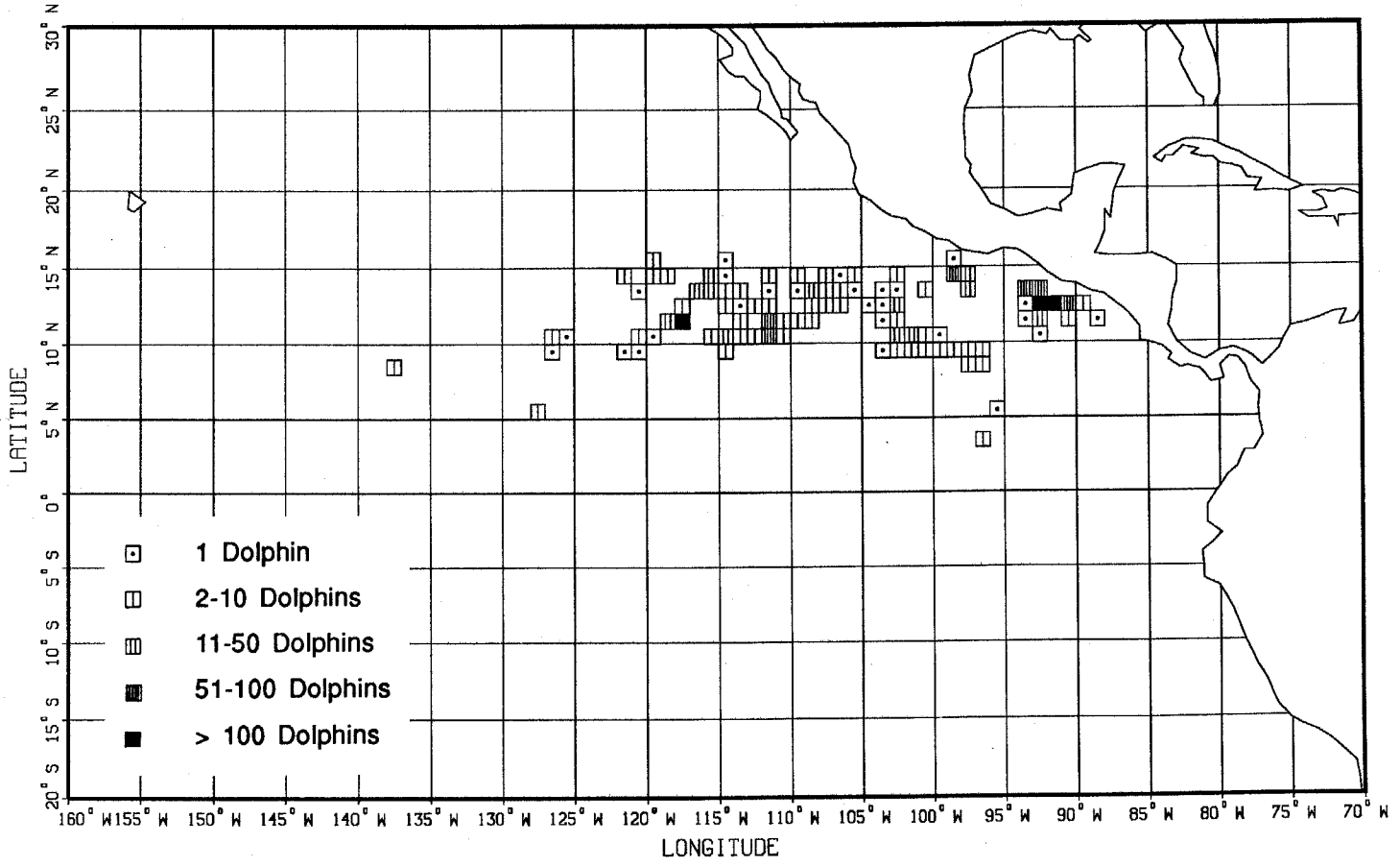

Figure 3C. The total number of eastern spinner dolphins, by 1^{o} quadrats, killed on observed U.S. tuna purse seine trips in 1988.

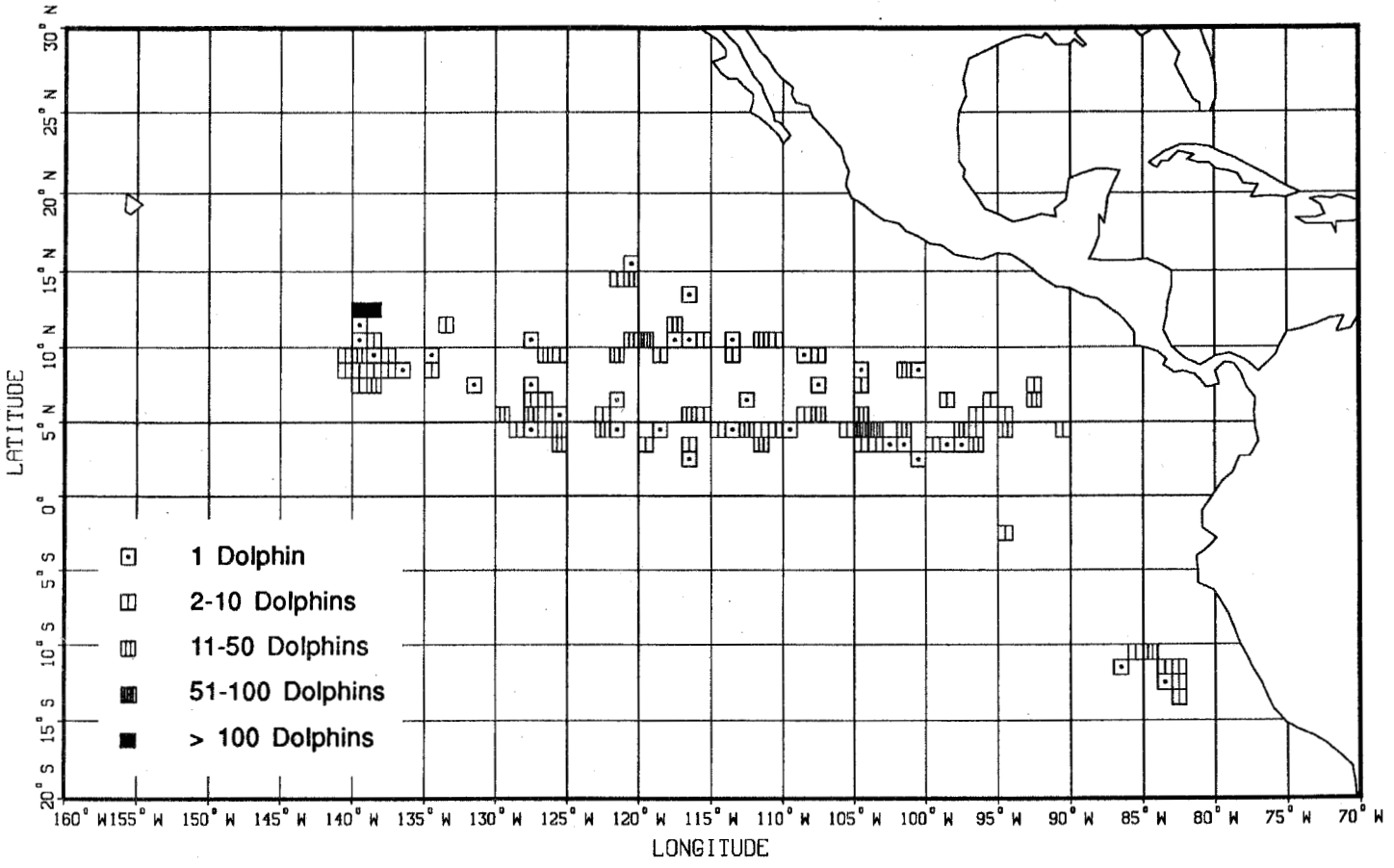

Figure 3D. The total number of whitebelly spinner dolphins, by 1^{o} quadrats, killed on observed U.S. tuna purse seine trips in 1988.

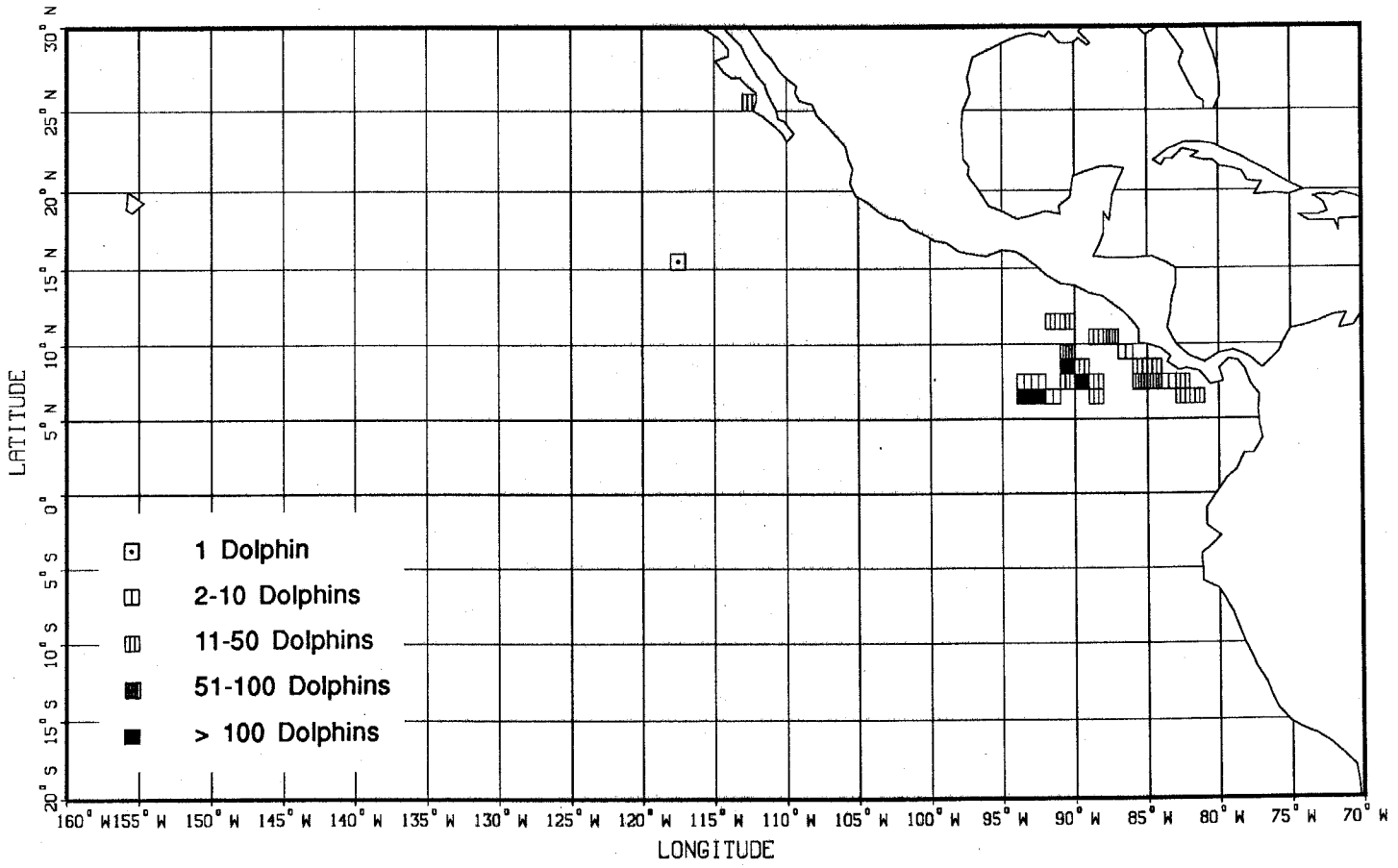

Figure 3E. The total number of common dolphins, by 1^{o} quadrats, killed on observed U.S. tuna purse seine trips in 1988.

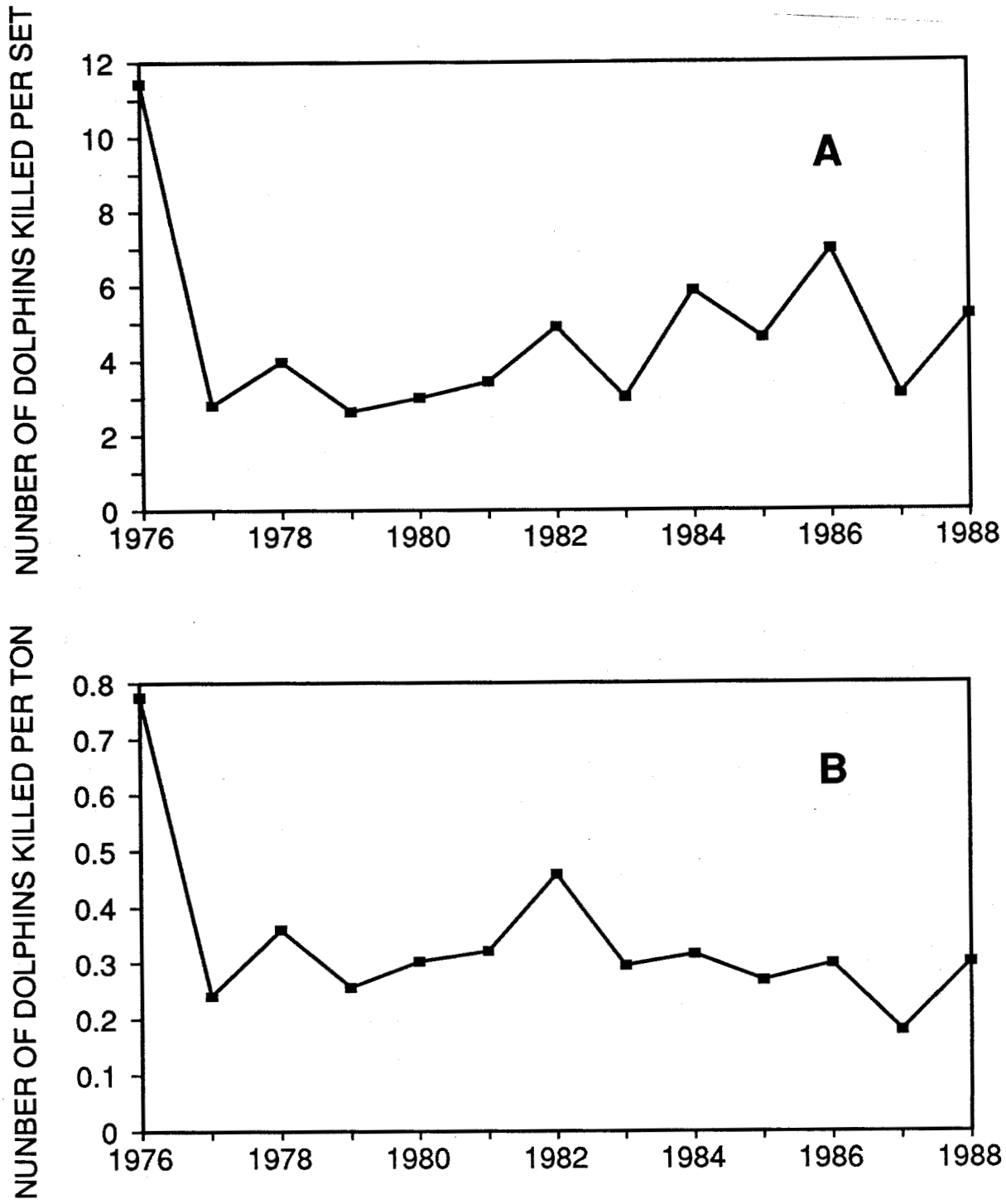

Figure 4 A: The dolphin kill-per-set rates, and B: kill-per-ton rates for observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean from 1981 to 1988.

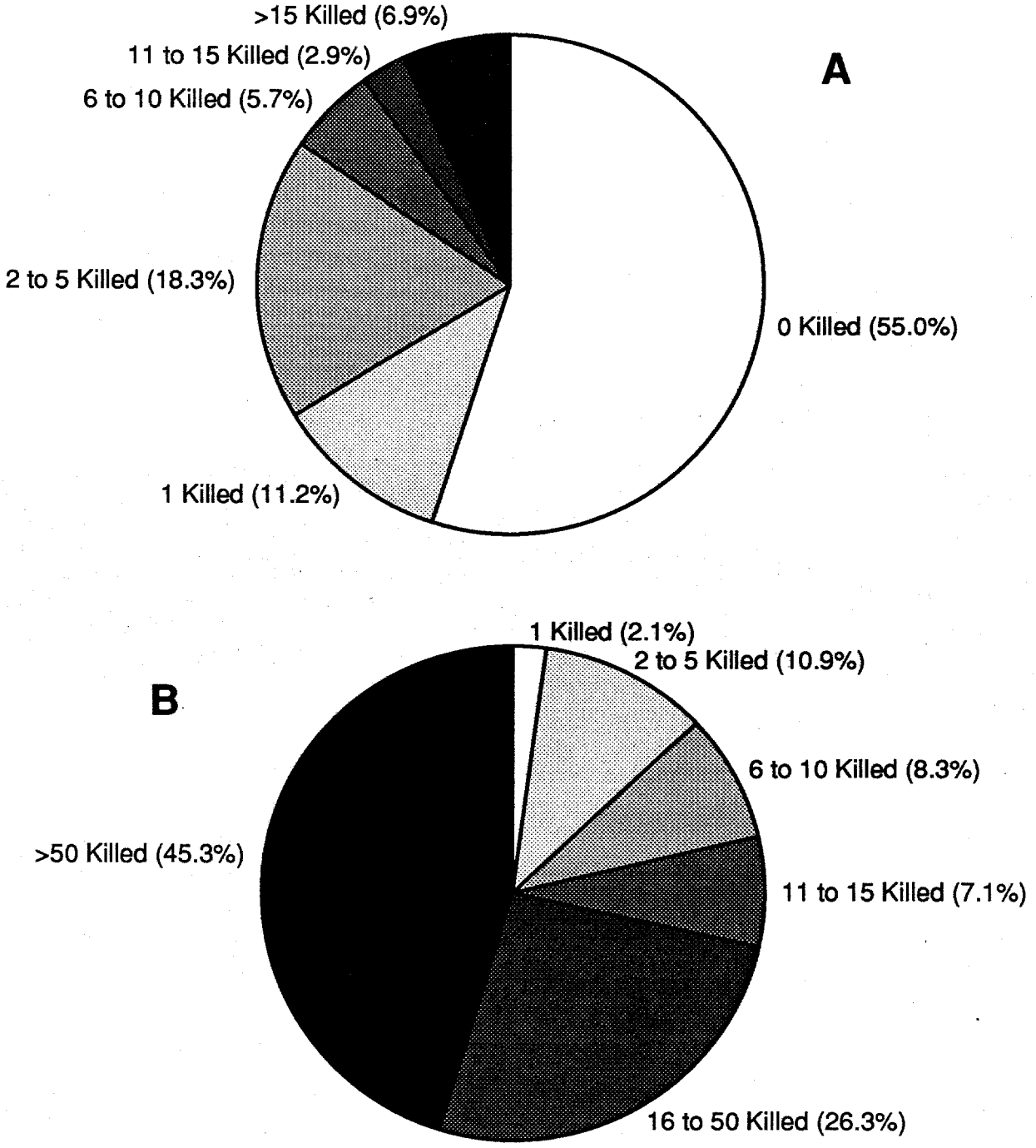

Figure 5 A: The proportion of all dolphin sets that resulted in dolphin mortalities of 0, 1, 2-5, 6-10, 11-15 and more than 15; and B: the proportion of the total dolphin mortality that resulted from sets with dolphin mortalities of 1, 2-5, 6-10, 11-15, 16-50 and more than 50, for observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean in 1988.

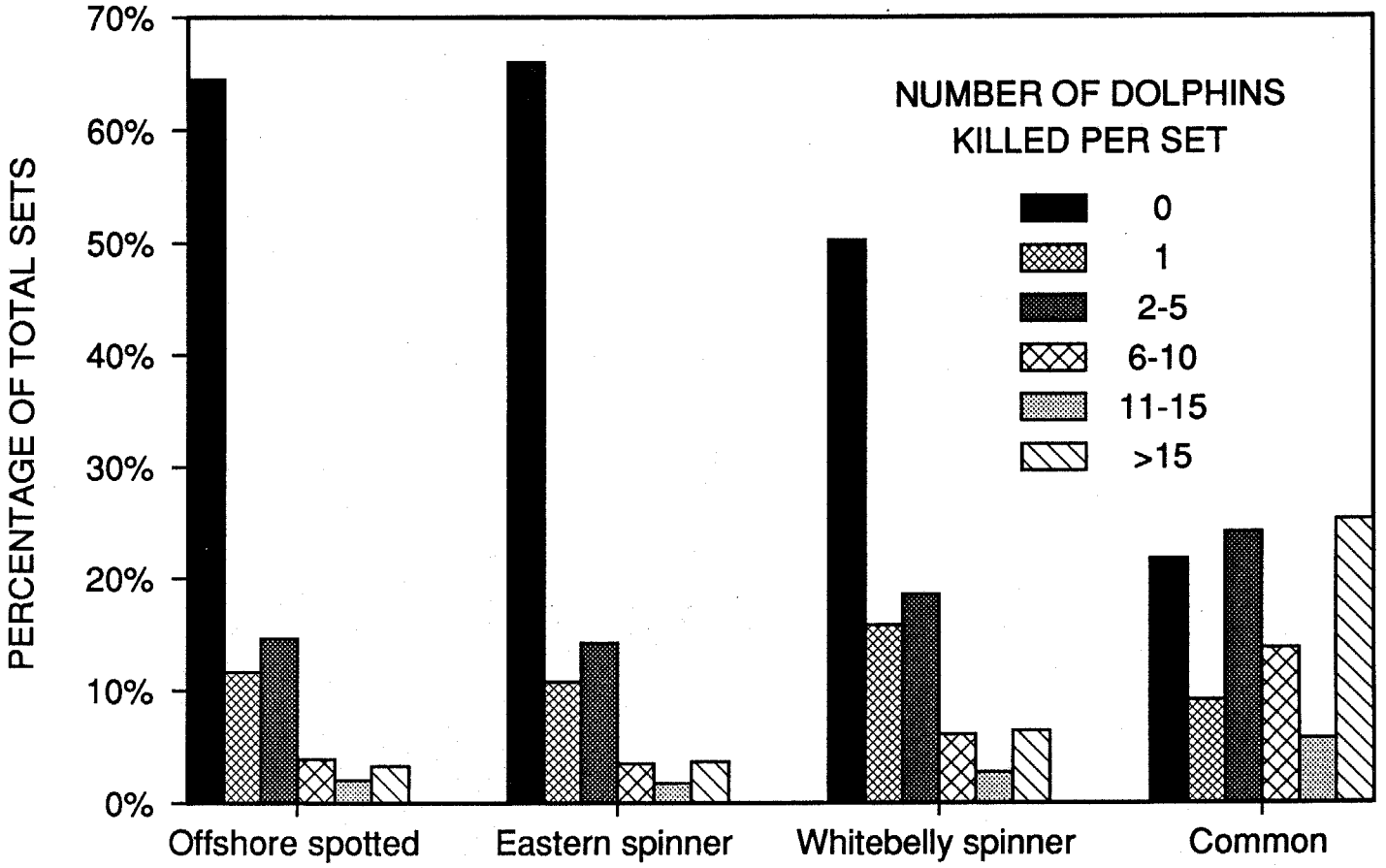

Figure 6. The relative frequencies of dolphin kill-per-set rates, by population, for observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean, 1988.

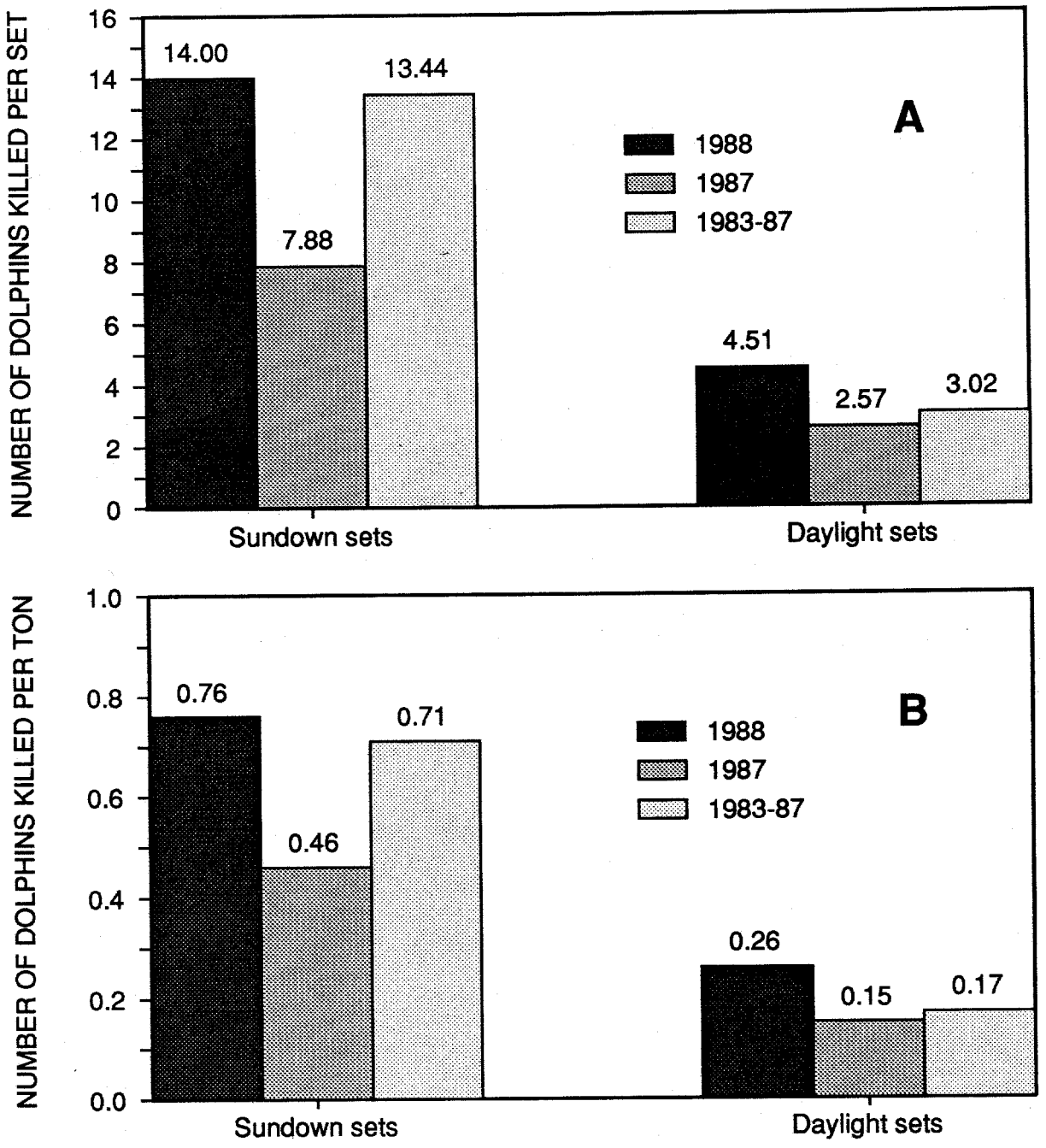

Figure 7 A: The dolphin kill-per-set rates, and B: kill-per-ton rates, by sundown sets versus daylight sets, for observed U.S. tuna purse seine trips in the eastern tropical Pacific Ocean in 1988, 1987 and the 1983-87 average.

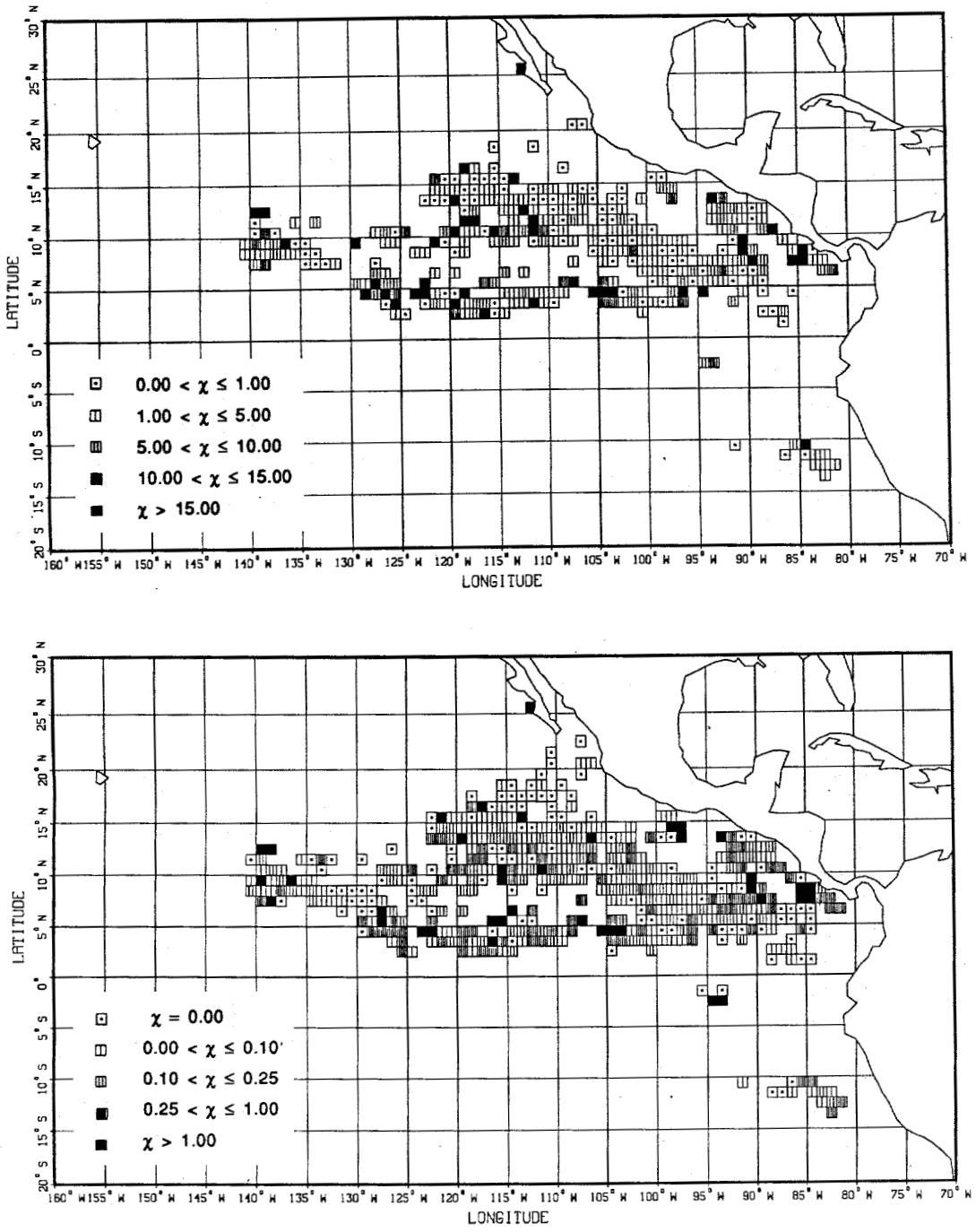

Figure 8 A:The dolphin kill-per-set rates, and B: kill-per-ton rates, by 1° quadrats, for observed U.S. tuna purse seine trips in 1988.

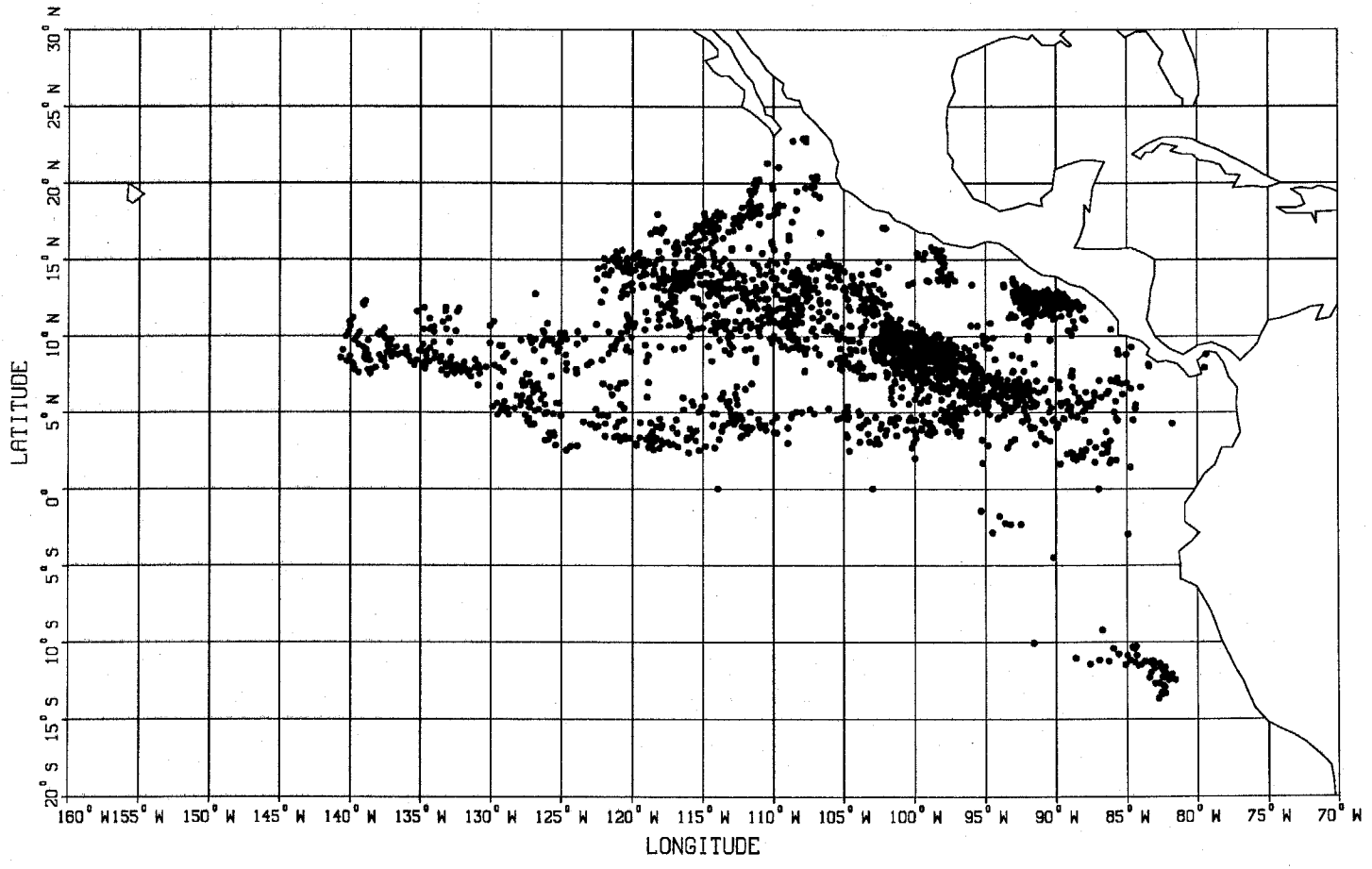

Figure 9A. Locations of offshore spotted dolphin sightings reported by observers aboard U.S. tuna purse seiners in 1988.

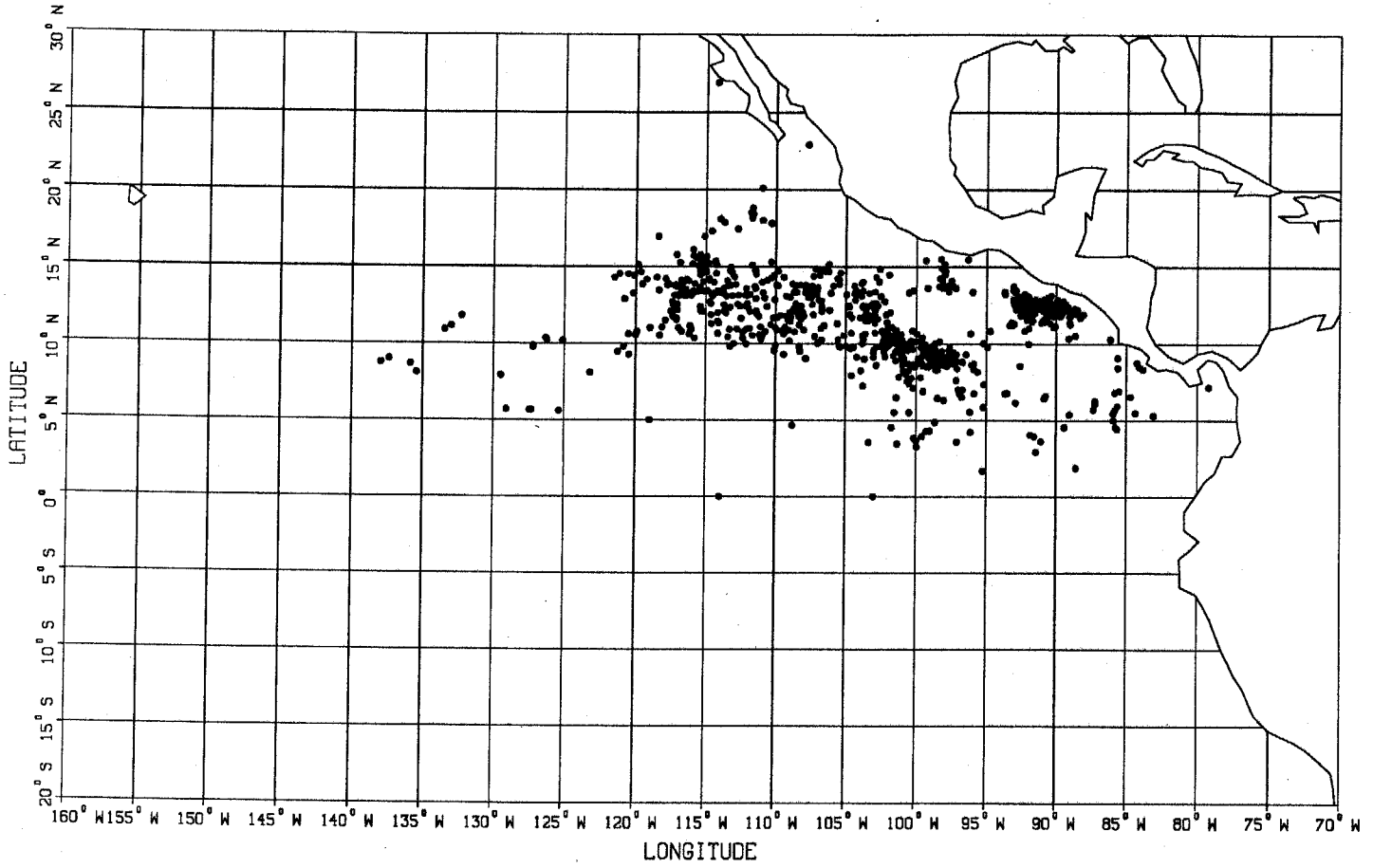

Figure 9B. Locations of eastern spinner dolphin sightings reported by observers aboard U.S. tuna purse seiners in 1988.

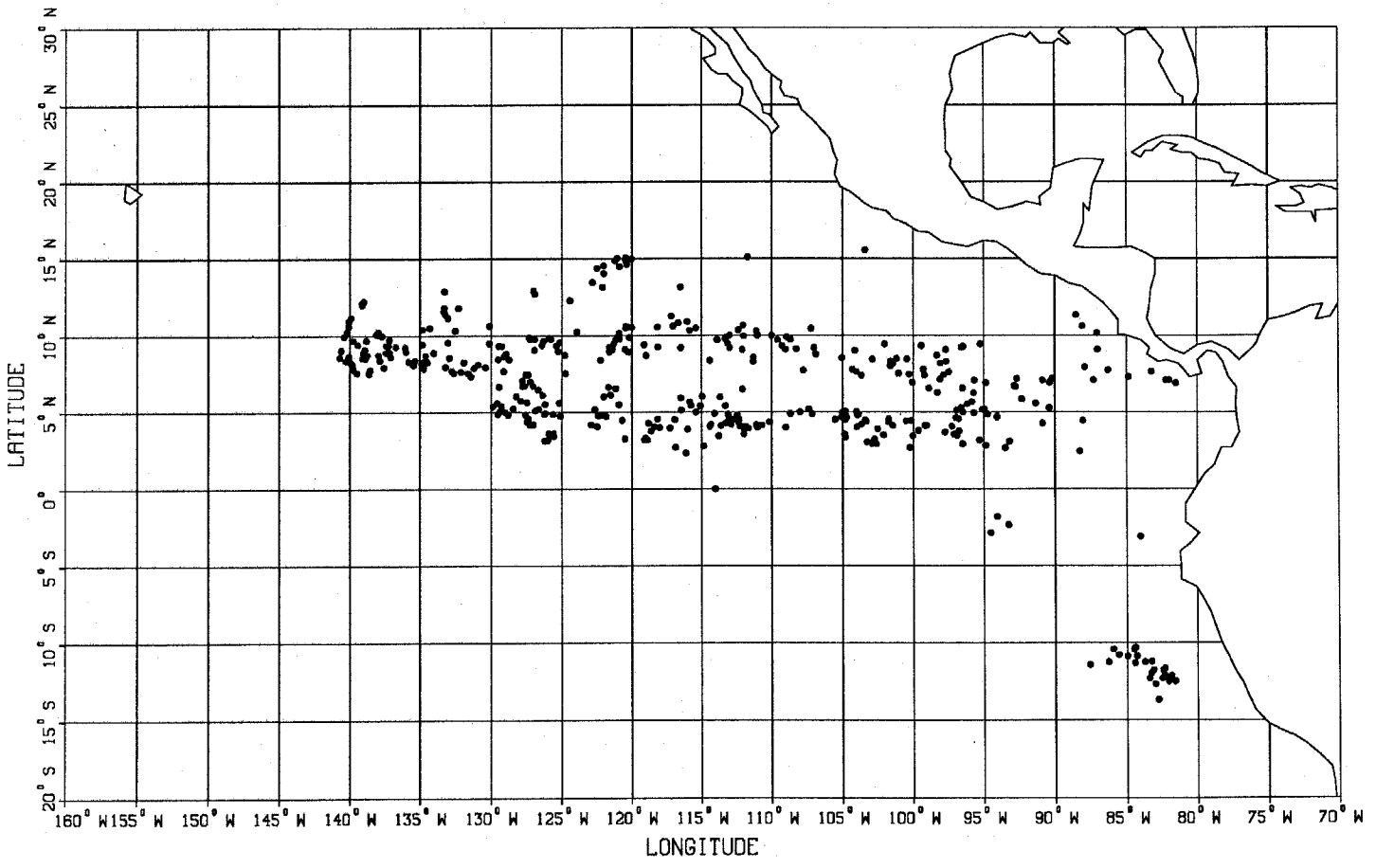

Figure 9C. Locations of whitebelly spinner dolphin sightings reported by observers aboard U.S. tuna purse seiners in 1988.

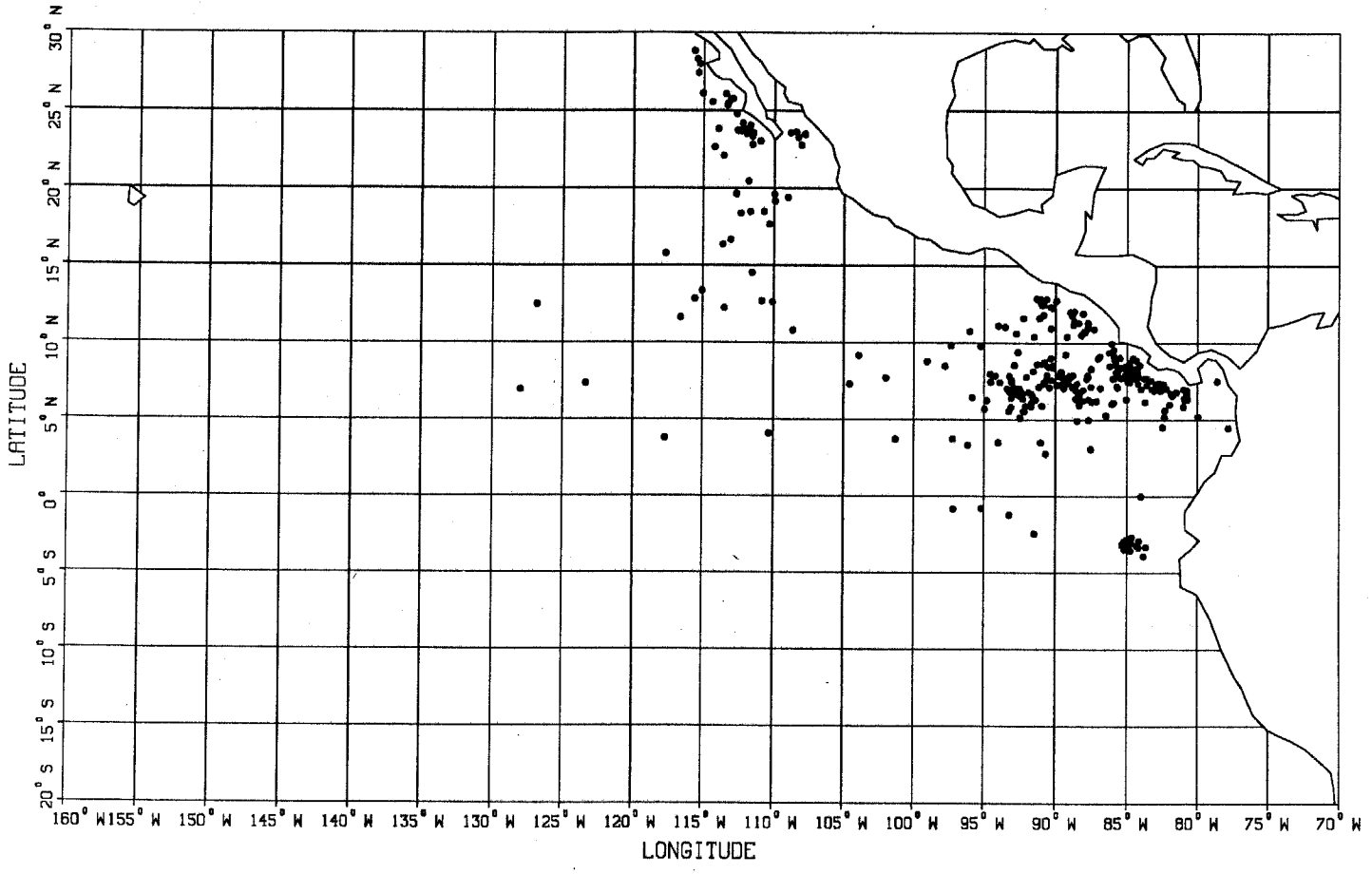

Figure 9D. Locations of common dolphin sightings reported by observers aboard U.S. tuna purse seiners in 1988.

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