CAPTAIN'S REPORT

MULTI-SPECIES CATCH CHARACTERISTICS for the U.S. ATLANTIC PELAGIC LONGLINE FISHERY

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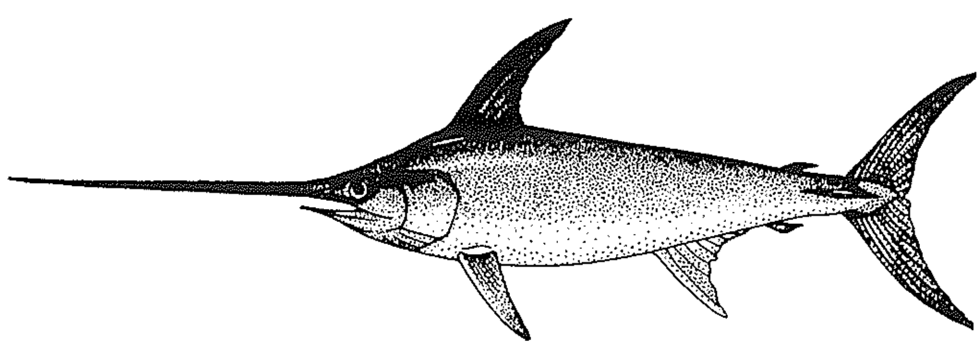


INTRODUCTION

Pelagic (free floating) longline gear, illustrated in Figure 1, consists of a continuous mainline, which is supported by float lines (droppers) and includes regularly spaced branch lines that end with baited hooks (gangions). Longline gear was traditionally used by the Japanese for harvesting tuna in open ocean waters around the Japanese archipelago from at least the 1930s (Sakagawa, Coan, and Bartoo 1987). Pelagic longline gear was introduced into the western North Atlantic tropical yellowfin fishery in the late 1950s by the Japanese. United States and Canadian fishermen adopted the nighttime use of pelagic longline gear for swordfish in the early 1960s. Spain has reported longline landings from the eastern North Atlantic since the early 1940s (Rey and Garces 1982). Brazil, Portugal, Venezuela, and Uruguay have well-established longline fisheries that target swordfish. Japan, Korea, and Taiwan maintain extensive longline fleets that target Atlantic tunas.

Although the general design of pelagic longline gear is relatively simple, operating characteristics (including area, month, time of set, surface temperature, fishing depth, bait, etc) have been found to affect significantly the catch rates and mix of species caught. Differences in species composition and catch rates between the directed effort for tuna, swordfish, and shark have been documented (Hoey 1983, 1995). Analyses have also indicated that changes in gear rigging, primarily deeper-rigged designs, can increase bigeye tuna catch rates and reduce catches of other species. (Suzuki, Warashima, and Kishida 1977; Nakano, Okazaki, and Okamoto 1997).

Deeper-rigged designs take advantage of the fact that the mainline between two floats forms a catenary and this depth can be affected by setting more hooks between floats or by adjusting the speed of the vessel during gear deployment. Sakagawa, Coan, and Bartoo (1987) concluded that longline gear could be deployed in specialized ways to catch more of certain species than others, and that these operational characteristics should be evaluated in terms of fishing effectiveness in stock assessments. This report will provide quantitative data on the multi-species catch associated with different operating conditions and practices.

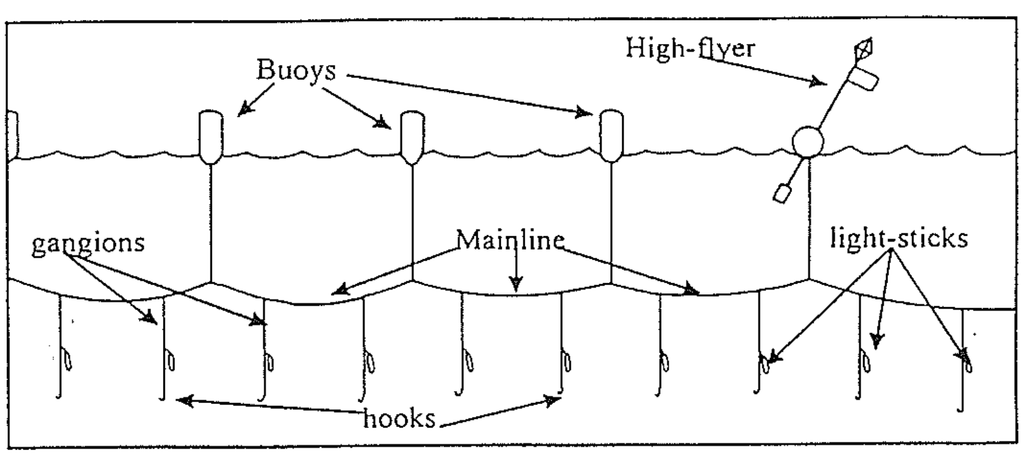


FIGURE 1. Typical U.S. pelagic longline gear diagram (from Arocha, 1996).

BACKGROUND

In this report, **bycatch** refers to the **portion of the multi-species catch that is discarded or released at sea (both dead and alive) for economic, legal, or personal reasons.** The **retained catch** includes **primary target species actively sought by the fishermen** and **secondary market species** *(sometimes called non-target catch)* that are **incidentally caught and retained either for sale or personal consumption. Primary target species** include swordfish, and yellowfin and bigeye tuna. **Secondary market species** include other tunas, pelagic and coastal sharks, and a variety of edible fish. Generally, strategic decisions relating to when, where, and how the gear is set are based on the catch rates of the primary target species. Target species may change during the course of a single trip. Bycatch, as defined previously, includes individual animals that are target and secondary market species that are not retained.

The impact of longline fisheries on populations of incidentally captured species will depend on: (1) how often they are captured, and (2) the proportions that are released alive and survive, or are dead, either kept or discarded. The biological effect of a particular fishery on an incidentally-captured stock depends on the size of the population and mortality from other fisheries. The absence of comparative studies of other fisheries and limited estimates of population sizes for the incidentally captured species prevent incidental catch statistics from this or many other fisheries from being placing in a reasonable biological or stock context. An objective evaluation of bycatch (discarded/released catch) for any multi-species fishery must distinguish between marketable and non-marketable species and identify the reasons why different species are disposed of differently (e.g., sold, released alive, and discarded dead).

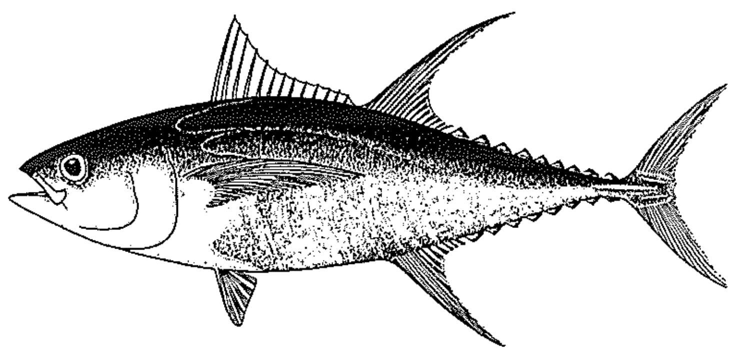
Management programs frequently consider the catch of secondary market species (non-target catch) as a "bycatch" management issue. In these programs, regulations are required to control the size of that catch to ensure effective management of the stocks and to reduce user conflicts with other commercial or recreational fisheries that may target those species. Whether the non-target catch is discarded or retained, cooperative research to support more selective fishing is in the best interest of vessel owners and captains and will be required to satisfy national and international management objectives.

Growing worldwide concern about incidental harvests of non-target species and waste in commercial fisheries has drawn attention to the operating practices of a number of fisheries. Constructive discussions about the relative selectivity of different fishing gears and the effect on incidentally harvested species have been hampered by limited quantitative studies and confusion caused by inconsistent definitions of key terms (e.g. target species, bycatch, selectivity, etc.). Attention has also been focused on glamorous or "charismatic" species that are often rare components (in numbers) of the incidental catch, such as marine mammals. The vast majority of world fisheries, both commercial and recreational, are fundamentally multi-species in nature. Perfectly selective fisheries — capturing only one species — are rare. Unfortunately, the term "bycatch" means different things to different people. "Bycatch" management has been confounded with allocation decisions and the negative connotation associated with the term now hampers collaborative efforts to address the problem.

United States vessels use pelagic longline gear throughout the western North Atlantic from the North coast of South America to the Azores. While swordfish and yellowfin tuna are the primary target species, a few other tunas (albacore, bigeye, blackfin), finfish (mahi-mahi, Escolar, wahoo, etc.), and several shark species (mako, porbeagle, sandbar, blacktip) contribute to the total marketable catch. Many fisheries rely on the capture and marketing of several ecologically-related species to provide the income that sustains these small businesses. Additionally, nonmarketable species, several regulated species, and damaged or spoiled individual species that are caught are frequently discarded dead or alive. Observers indicated that damaged individuals alone accounted for 4% of the total number caught. Regulated species include billfish (marlin, sailfish, and spearfish), undersized swordfish, and bluefin tuna and large coastal sharks once trip limits or quotas are filled. Protected species include sea turtles, birds, and marine mammals. Protected and regulated species must be discarded or released by law. Observer data indicate that many of these incidental species are infrequently encountered and usually released alive, yet the extent of these interactions in pelagic longline fisheries and the unknown cumulative magnitude of incidental mortality from several nation's fleets have raised concern.

Evaluating the operating characteristics and the resulting multi-species catch (in particular, unusually high incidental catches) provides an opportunity to identify gear and fishing practices that minimize bycatch while maintaining profitable target species catch rates, which is already a common strategy for longline captains. Boggs' (1992) field work using hook timers and time-depth records to evaluate differences in capture depth by species for different gear configurations is particularly appropriate. Observer data summaries provide captains with information from a greater number of areas and about gear and operating styles that he or she might not normally experience.

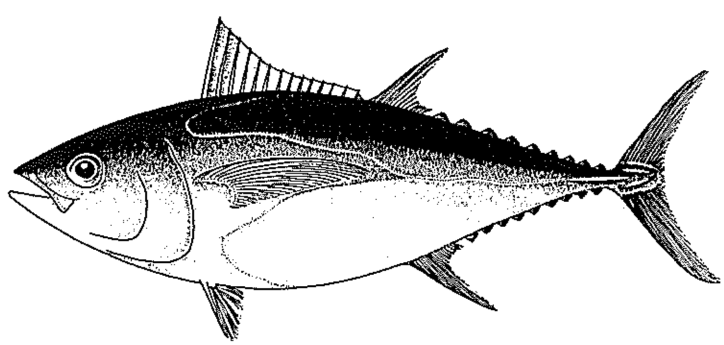
The goal of this report is to encourage more extensive experimentation with operating practices and gear configurations so that captains have a greater variety of options to use to minimize incidental bycatch. Without efforts to practice more selective fishing, alternative regulatory options to reduce bycatch could be more intrusive and possibly negate the flexible and adaptive characteristics of the gear.



DOCUMENT ORGANIZATION

This report describes the observer program, the data collected, and how the data are summarized. In the initial summary of the multi-species catch characteristics, a portion of the observer data (specifically, sets that targeted sharks) is separated from the remaining pelagic swordfish and tuna effort. This illustrates the differences in operating practices affecting species selectivity. Catch composition and disposition summaries are provided for the observed pelagic longline sets. A second example illustrates differences in selectivity based on the time of day the gear is set and retrieved. Average daily performance statistics are provided by geographical area to characterize more thoroughly how the fishery operates. Subsequent regional summaries characterize catch, disposition, and observed operating practices.

Finally, specific circumstances that disproportionately affect bycatch rates for certain species are described. Distribution maps are provided for a number of target and bycatch species. In those cases where the data and analyses support alternative operating procedures, recommendations are provided.



DATA SOURCES AND COVERAGE

The National Oceanic and Atmospheric Administration (NOAA)/NMFS observer program for U.S. Atlantic pelagic longline fisheries has deployed observers from both NEFSC and SEFSC since 1990. Between 1990 and 1997, observers have been deployed on 452 trips accounting for 3,397 sets and 2,236,867 hooks set (Table I). Observers recorded the capture status and disposition of 115,398 individual animals (all species) on both pelagic and demersal longline sets.

The observed trips covered a vast expanse of the western North Atlantic and monthly observations were variable within areas, especially for northern and distant offshore areas. While some of this variability reflects funding cycles, it also reflects the tracking of a seasonally migrating fleet that is targeting migrating predatory species. Figure 2 displays the standard reporting areas used throughout this report. These are a modification of reporting areas for pelagic logbook, observer, and ICCAT landing reports developed by the SEFSC (Cramer, 1996). The number of observations within several of the original areas, specifically Cramer's areas 8, 10, and 11, were extremely limited. Because of regulations relating to disclosure of confidential data, observations from area 8 are combined with area 9 (WNCA), and data from areas 10 & 11 are combined into a single area (TROP). With respect to the latter area, the very limited number of observed trips occurred in the last year (1997) of the time series. Given these characteristics, any conclusions with respect to catch characteristics for the TROP area and/or comparisons with other areas are unreliable.

TABLE I. Annual totals for trips, sets, hooks, and the number of animals caught from the NMFS Pelagic Longline Observer Program. Totals for sets, hooks, and catch are summarized by the year of the set retrieval. For trips, the total reflects the date of the first set on the observed trip.

YEAR	TRIPS	SETS	HOOKS	CATCH NUMBER
1990	2	23	14,885	632
1991	5	48	32,495	2,603
1992	45	332	199,386	12,284
1993	109	827	540,357	27,072
1994	92	651	423,517	22,333
1995	91	699	486,499	23,714
1996	51	362	224,155	9,397
1997	57	455	315,573	17,363
TOTAL	452	3,397	2,236,867	115,398

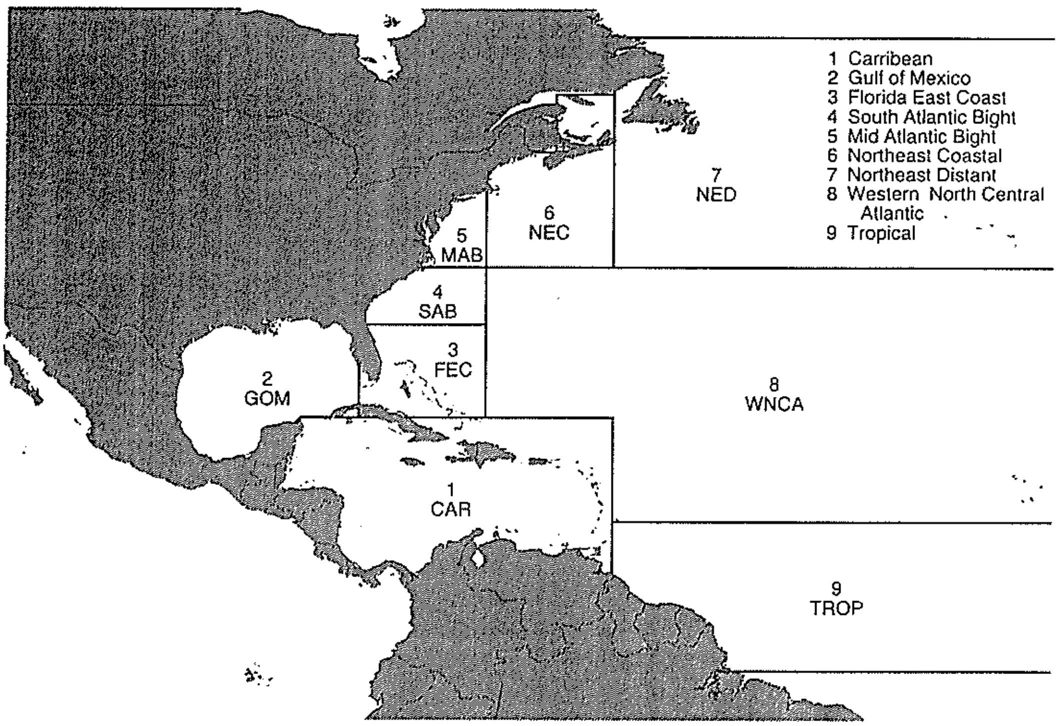
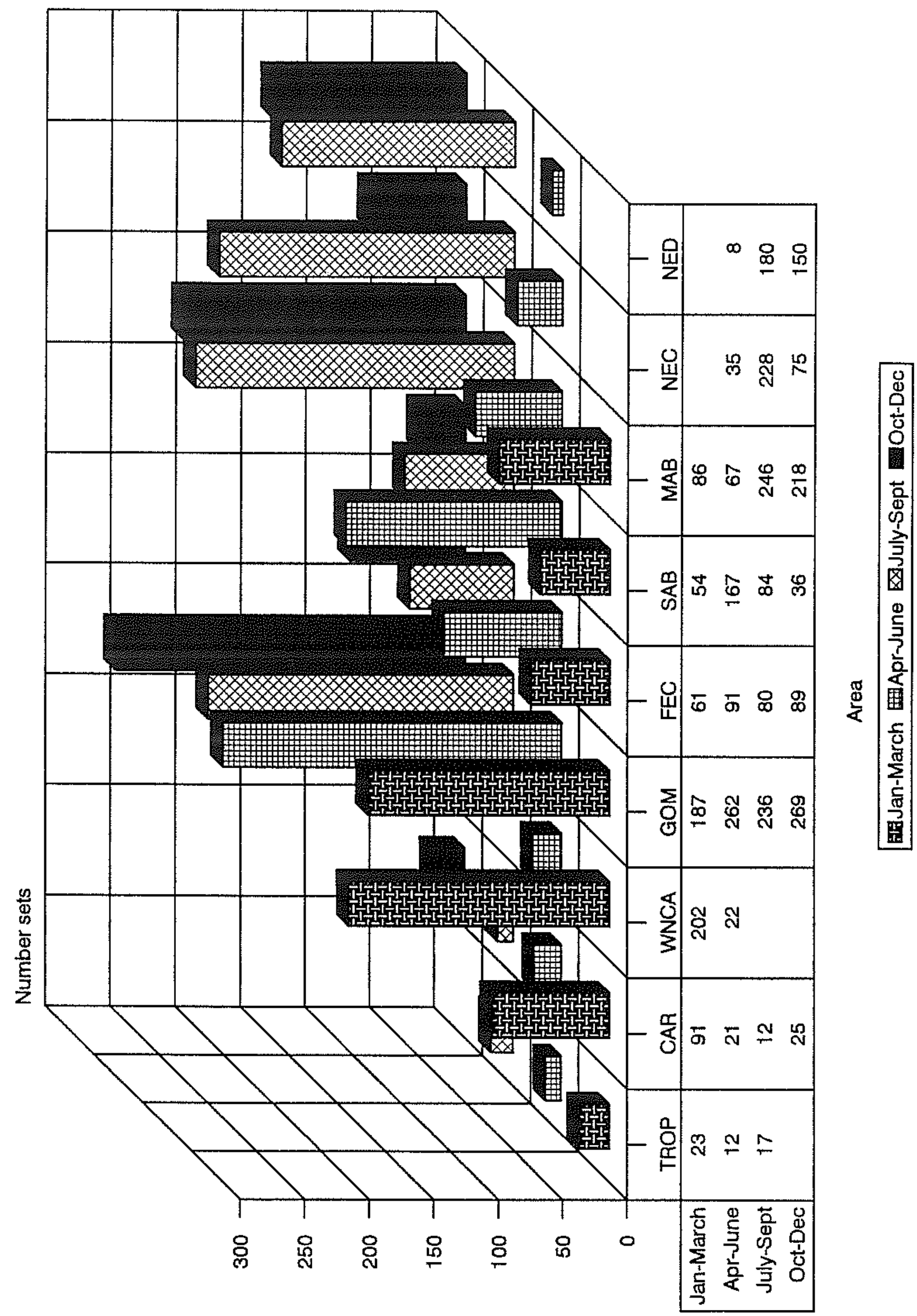


FIGURE 2. The standard reporting areas used throughout this report (Modified from Cramer 1996).

Statistical Caveats

While there are data from 452 trips and 3,397 sets, with nine geographical areas and four seasons (9x4=36) or 12 months (9x12=108), the number of time-area strata are also large, leading to time/area strata represented by limited numbers of observations. Figure 3 illustrates sampling differences between areas and quarters. Limited observations (sets) in some area-quarter strata reflect seasonal distribution patterns of the target species and surface water temperatures. Additionally, sets within a trip are usually similar because the range of gear and operating changes a captain will make is logistically limited. If extra gear components, such as different lengths of hook lines, are not on board, options to change gear will be limited by the ability of the crew to manufacture or rig existing gear differently between daily setting and hauling operations. In simple terms, the number of independent observations in terms of statistical power is less than 3,300 and probably much closer to 452 trips. This clearly can influence the reliability of conclusions drawn from comparing catch rates within and between area-time or area-gear comparisons.



	TROP	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Jan-March	23	91	202	187	61	54	86		
Apr-June	12	21	22	262	91	167	67	35	8
July-Sept	17	12		236	80	84	246	228	180
Oct-Dec		25		269	89	36	218	75	150

FIGURE 3. Number of observed pelagic longline sets by area and quarter, 1990 to 1997; total sets: 3,334.

DATA ELEMENTS

Observer coverage provides detailed records on each trip, each set and haul, gear configuration, and biological observations on the animals caught. Vessels are randomly selected based on the number of sets they reported by area and quarter in the mandatory logbooks for the preceding year. Standard forms and recording procedures result in separate files for trip, set, gear, and haul records, which track more than 150 variables. Additionally, biological observations (animal records) include species identifications, size estimates (length, weight, or both), condition (alive, dead), disposition (kept, discarded), and other sampling codes. Table II lists some of the important trip, set, haul, and gear variables used in subsequent analyses.

TABLE II. Standard data elements for pelagic longline observer records, trip, gear, set, and haul variables.

TRIP IDENTIFIERS	**GEAR VARIABLES**
Source (NEFSC - SEFSC)	Mainline Material
Landing Year	Number of Strands Mainline
Landing Month	Mainline Pound Test
Trip ID Code	Miles Mainline Set
Set Number	Gangion Material
	Gangion Pound Test
SET VARIABLES	
Begin Set & Haul Dates – (Month – Day – Year)	Dropper Lengths (Minimum, Maximum, Average)
Time - 24 hour clock – (Begin Set, End Set, Begin Haul, End Haul)	Gangion Lengths (Minimum, Maximum, Average)
Temperature - °F (Begin Set, End Set, Begin Haul, End Haul)	Hook Variables for 2 hooks per set (Brand, Pattern Number, Size)
Quarter	Leader Used (Yes or No)
Gear Type (pelagic, bottom, shark)	Leader Material
Statistical Area (areas 1 to 11)	Swivel Used (Yes or No)
Latitude (Begin haul degree and minutes)	Number of Swivels
Longitude (Begin haul degree and minutes)	
Bottom Depth (Avg. Meters)	Bait Variables for 2 baits per set
	- Bait Kind – Species
Hooks Set & Hauled	- Bait Type – whole – cut – live
Line Thrower Used (Yes or No)	- Bait Condition – Fresh – Frozen
Light Sticks Used (Yes or No)	
Number of Light Sticks	
Hook Tending (Yes or No)	
Number of Hooks between Floats	

SPECIES RECORDS

For individual animal records, observations must be combined or assigned to specific species/species groups. There are records that cannot be assigned to a specific group because the animal either broke the gangion or threw the hook before it could be identified (unknown animals are less than 1%). Other records are coded to a group code (e.g. unidentified tuna, billfish, shark, finfish, etc.), or species group (e.g. thresher, mako, hammerhead, spearfish), rather than to a specific species code. Between 80 and 90 unique codes exist for species, species group, group, and unclassified records. Approximately 30 to 35 species were also recorded 10 or fewer times out of the more than 110,000 animals observed.

In order to simplify the presentation of species composition data and to facilitate the estimation of the total weight caught by species or species group, consolidation of codes was necessary. Initially, the 80 to 90 codes were combined into 41 groups used in analyses of recorded sizes (either length or weight). After matching and substitution routines[1] assigned body weights to all records, 21 species categories were established as the standard groups for subsequent table summaries and graphics. In Table III, the 21 major groups are capitalized, while the 41 matching groups are associated with the total numbers caught by pelagic longline effort. Several of these categories reflect groups used in Atlantic fishery management plans (i.e., large and small coastal sharks).

TABLE III. A total of 21 major species groups (capitalized) and matching groups (those with associated catch numbers from pelagic longline effort) were used to summarize observed longline catches. Major groups can also be matching groups.

SWORDFISH	(27.930)	BLUE SHARK	(19,264)	MAHI (DOLPHIN)	(8,566)
TUNAS		MAKO SHARKS	(1,726)	LANCETFISH	(3,677)
YELLOWFIN	(17,179)			OILFISHES	
BIGEYE	(6,762)	OTHER PELAGIC SHARKS		Escolar	(2,935)
BLUEFIN	(765)	Thresher Sharks	(348)	Oilfish	(456)
ALBACORE	(2,676)	Porbeagle Shark	(45)	WAHOO	(762)
		Oceanic Whitetip	(262)	OTHER FISH	
OTHER TUNA	(1,511)			Mola (sunfish)	(240)
Blackfin tuna		LARGE COASTAL SHARKS		Unknown	(1.070)
Skipjack		Dusky shark	(1,122)	Mackerel	(200)
Little Tunny		Silky shark	(1,905)	Bluefish	(61)
Bonita		Hammerhead Sharks	(725)	Misc. Finfish	(947)
Unid. Tuna		Blacktip shark	(92)		
		Sandbar Shark	(333)	SKATES & RAYS	(4,863)
MARLIN		Tiger Shark	(351)		
Blue Marlin	(998)	Other Large Coastals	(274)	PROTECTED RESOURCES	
White Marlin	(1,613)			Birds	(65)
SAILFISH/SPEARFISH		SMALL COASTAL SHARKS	(29)	Loggerhead Turtles	(283)
Sailfish	(1,114)			Leatherback Turtles	(214)
Other Billfish	(304)	OTHER SHARKS		Other Turtles	(31)
		Dogfish	(27)	Mammals	(90)
		Unidentified Sharks	(555)		

[1] Substitution routines refer to programs that substitute average weights from measured species/species groups to those individual animals within the same species/ species group that did not have observer recorded sizes.

INITIAL DATA SUMMARY

Shark versus pelagic longline sets

The 452 observed trips (3,397 sets) included effort directed at swordfish, yellowfin and bigeye tuna, as well as sets directed at sharks. Trips that targeted sharks included 11 bottom (demersal) sets and 52 semi-pelagic sets, where gear and operational changes indicated that the captain adopted a specific strategy targeting sharks. Figure 4 presents a species composition histogram (in descending order of numerical abundance) for the directed shark sets (n=63), while Figure 5 presents the same information for the observed pelagic longline sets (n=3,334). The latter figure includes observations from a variety of areas, months, and operating styles that combine different fishing strategies, including the targeting of tuna, under some conditions, and swordfish, under others.

Seven trips targeted sharks exclusively and they were initially identified as deploying only bottom longline gear, or as unusually large total trip catches of coastal sharks with few other species recorded. Observer notes confirmed that these were shark trips. Four additional trips were identified because of unusually large catches of coastal shark species, however, these trips also had significant catches

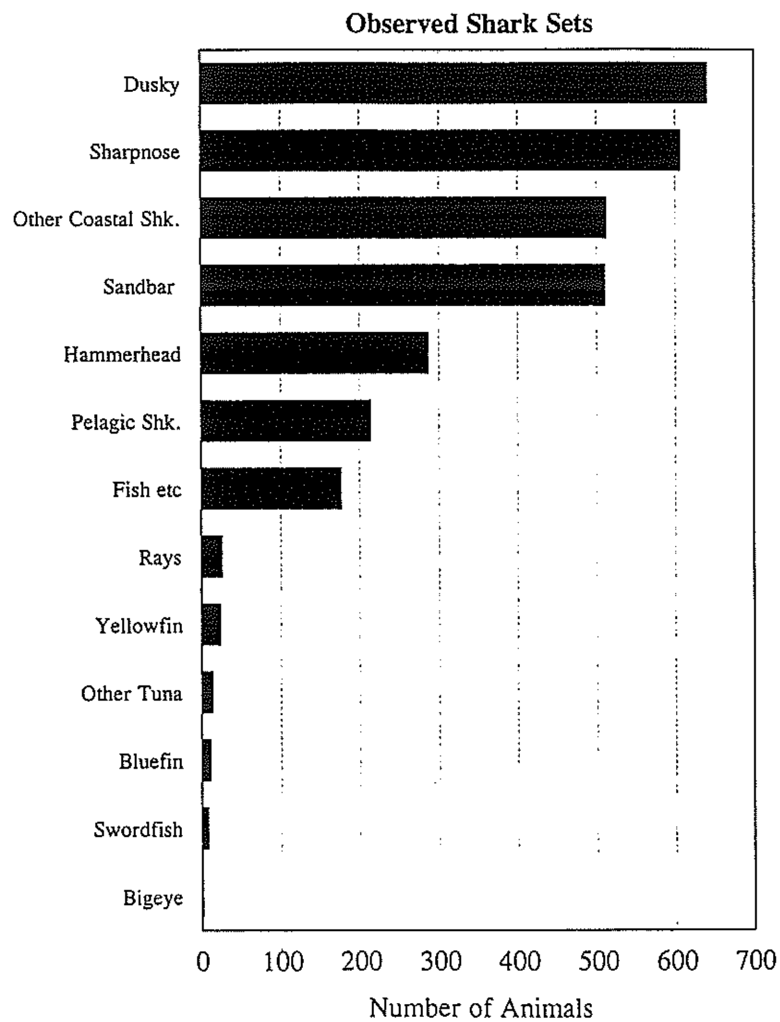


FIGURE 4. Species composition histogram in descending numerical order of abundance for 63 sets that targeted sharks.

of swordfish and tuna. The individual set records for these trips revealed that several sets during each trip accounted for a disproportionate coastal shark catch and very few swordfish or tuna. These sets were considered outliers because of the number of hooks set between floats and because the pound test for the gangions matched the mainline pound test. Additionally, the average bottom depth over which the sets were made was shallower than the depths usually fished for swordfish and tuna, indicating that the captain was modifying his or her fishing strategy within a trip, most likely to take advantage of the open season (quota) for coastal sharks. The combination of larger numbers of hooks between floats (from 10 to 30 or more versus the usual four or five) and shallower bottom depths indicate that the active fishing depth was loser to the bottom than for the other sets within these trips. Once again, observer notes corroborated that these sets were directed at sharks.

While the 63 identified shark-targeted sets represented less than 2% of the total observed sets, they accounted for 32.2% of the total large coastal shark catch. Further, these sets accounted for 97% of the sharpnose sharks, 60% of the sandbar, 57% of the blacktip, and 36% of the dusky sharks. Accounting for these identifiable changes in fishing strategy by removing these records from a sample that characterizes effort directed at swordfish and tuna significantly affects the estimates of the incidental catch of large coastal sharks by pelagic longline effort.

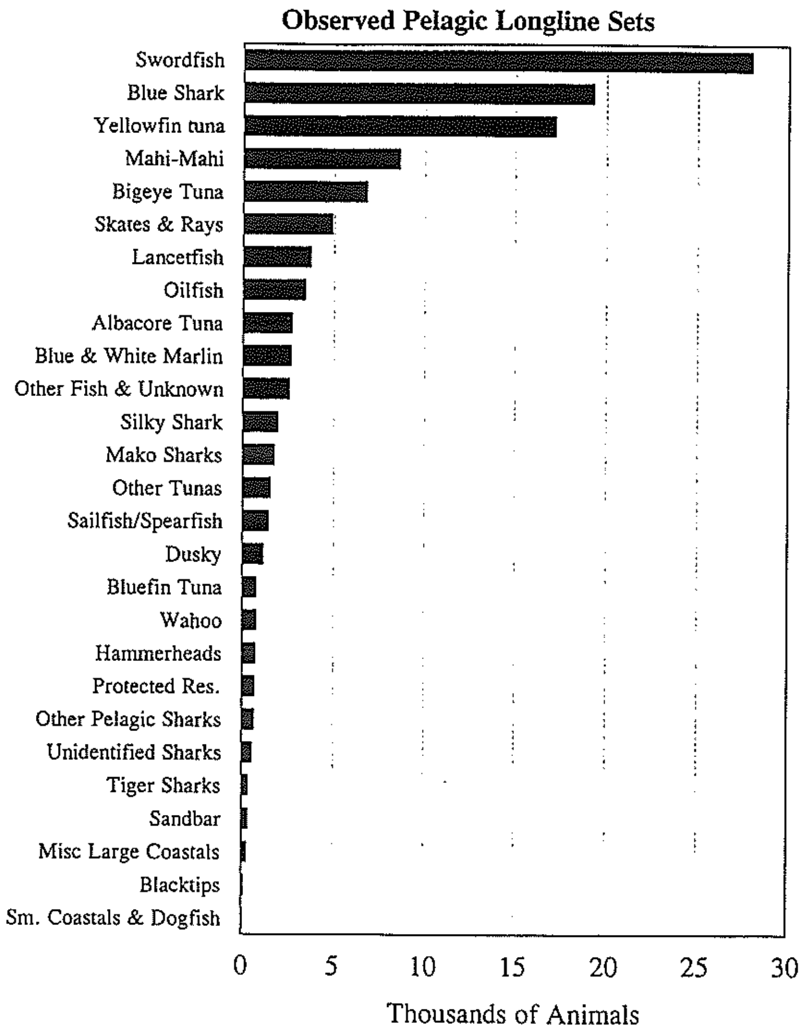


FIGURE 5. Species composition histogram in descending numerical order of abundance for 3,334 pelagic longline sets.

PELAGIC LONGLINE SETS

Catch composition

Table III lists the total numbers caught for each of the 41 species/species groups used to estimate the total live weight of the observed longline catch. The preceding pelagic longline histogram (Figure 5) presents the species selectivity pattern in descending numerical order. While that figure included species counts for several large coastal sharks to allow comparison with the shark effort histogram, subsequent figures will use the 21 major species/species groups listed in Table 3. Additionally, subsequent graphic depictions of species compositions for pelagic effort and comparative regional figures rank species based on the estimated total round weight of each species/species group caught.

Table IV lists the numbers caught and the estimated total weights along with relative rankings, in numbers and weight, in descending weight order for each species/species group. Weight based rankings affect the relative order of species because of the differences in average size. While the top three species account for 57.3% of the number caught, in weight these same species account for 66.1% of the total weight caught. Within the top ten, the biggest change in rank order occurs for the largest species observed, i.e., marine mammals, leatherback turtles, and bluefin tuna. In contrast, lancetfish, which are numerically abundant (ranked 8th) fall to 20th place in weight because they average about five pounds per individual. In evaluating selectivity patterns, a weight based approach is appropriate, particularly for commercial fishermen who are paid by the total weight of the different species landed.

TABLE IV. Numerical counts and estimated total weights in descending order for each species/species group observed in the catch reported for pelagic longline sets.

SPECIES / SPECIES GROUP	NUMBER CAUGHT / (Numerical Rank)		WEIGHT CAUGHT / (Weight Rank)	
Swordfish	27,930	(1)	2,130,115	(1)
Yellowfin Tuna	17,179	(3)	1,323398	(2)
Blue Sharks	19,264	(2)	1,290,678	(3)
Bigeye Tuna	6,762	(5)	582,430	(4)
Large Coastal Sharks	4,802	(7)	343,668	(5)
Blue & White Marlin	2,611	(11)	239,498	(6)
Protected Resources	683	(18)	153,185	(7)
Mako Sharks	1,726	(13)	150,677	(8)
Albacore Tuna	2,676	(10)	146,293	(9)
Bluefin Tuna	765	(16)	135,341	(10)
Other Finfish	2,518	(12)	131,356	(11)
Mahi (Dolphin Fish)	8,566	(4)	114,342	(12)
Oilfishes	3,391	(9)	114,037	(13)
Skates & Rays	4,863	(6)	87,922	(14)
Other Pelagic Sharks	655	(19)	66,710	(15)
Sailfish/Spearfish	1,418	(15)	59,430	(16)
Other Sharks	582	(20)	32,470	(17)
Wahoo	762	(17)	30,290	(18)
Other Tunas	1,511	(14)	22,993	(19)
Lancetfish	3,677	(8)	18,671	(20)
Small Coastal Sharks	29	(21)	293	(21)
TOTAL CATCH	**112,370**		**7,173,797**	

PELAGIC LONGLINE SETS

Catch disposition

While weight-based ranks may more realistically reflect how commercial fishermen evaluate bycatch priorities, the numbers caught, the frequency with which particular species are caught, and their disposition must also be considered. Observers record whether individual animals are alive or dead when the gear is retrieved, kept or discarded/released, or injured or damaged — the latter reflecting shark and whale predation on the captured fish. Three categories summarize this disposition information by species/species group: kept, released alive, and discarded dead.

Figure 6 presents a catch disposition histogram in descending order of weight for the observed pelagic longline sets. It is important to emphasize that this figure includes sets from all seasons throughout the range of the U.S. Atlantic fishery as well as different targeting strategies. For the overall total catch, 56% of the weight is kept, 29% is released alive, and 15% is discarded dead.

Animals damaged by shark and whale predation and subsequently discarded are coded as "discarded dead." For all species/species groups, 4% of the catch in number was damaged, with yellowfin, swordfish, and bigeye tuna accounting for 68% of the total number damaged. Predation damage accounted for larger proportions of the tuna that were discarded dead than for the swordfish and other species discarded. While some of the damaged animals are kept and some released alive, the estimated weight of the damaged individuals discarded dead is 17% of the total estimated weight that was discarded dead (17% of 15%).

Figure 6 demonstrates differences in disposition patterns by species/species groups, while scaling the disposition components (kept, released alive, discarded dead) by their estimated total catch weight. While it is important to consider the significance each species/species group comprises of the total catch, this format makes it difficult to compare similarities in disposition patterns between species on the same scale (e.g. proportions kept, released, or discarded by species). Figure 7 presents each species/species group in a cumulative percentage format (each species sums to 100%) subjectively reordered to illustrate similarities in disposition patterns between species and their likely causes. This format eliminates the relative catch scaling provided by either numbers or weight, so both Figure 4 and Figure 5 should be examined simultaneously. Species/species groups have been arranged according to whether they are marketable, nonmarketable (including edible and inedible species with little U.S. market demand), or regulated species. While these groups are subjective and some individuals in each category are kept and sold, the categories generally reflect the forces (e.g. market and regulatory) that influence disposition decisions.

The first five marketable species listed (mahi-mahi, yellowfin, bigeye, wahoo and albacore tuna) are characterized by weight retention rates exceeding 85%. Small proportions are released alive and the weight discarded dead reflects limited markets for small individuals and/or predation damage. For mahi-mahi 45% of the number discarded dead were damaged, 77% for yellowfin, 63% for bigeye, 42% for wahoo, 41% for albacore, 93% for other tunas, and 9.8% for swordfish. For swordfish, 81% of the weight caught is kept, 5% is released alive, and 14% is discarded dead. Retained swordfish are much larger in average size than those that are discarded because swordfish minimum size regulations either limited the allowable catch below certain sizes (1991-1995), or prohibit possession completely (1996-1997). Two species of oilfishes are caught by pelagic longlines and, while the escolar is readily marketable, the true oilfish has purgative properties that the Food and Drug Administration cites to prevent its sale. The mako shark weight that was discarded dead (9%) was most likely small or damaged makos, individual animals that deteriorated in quality while dead on the line, or they were longfin makos. For small coastal sharks and other pelagic sharks, the dead discards primarily reflect limited markets because the flesh is inedible or at best, unpalatable. Bigeye threshers and longfin makos are

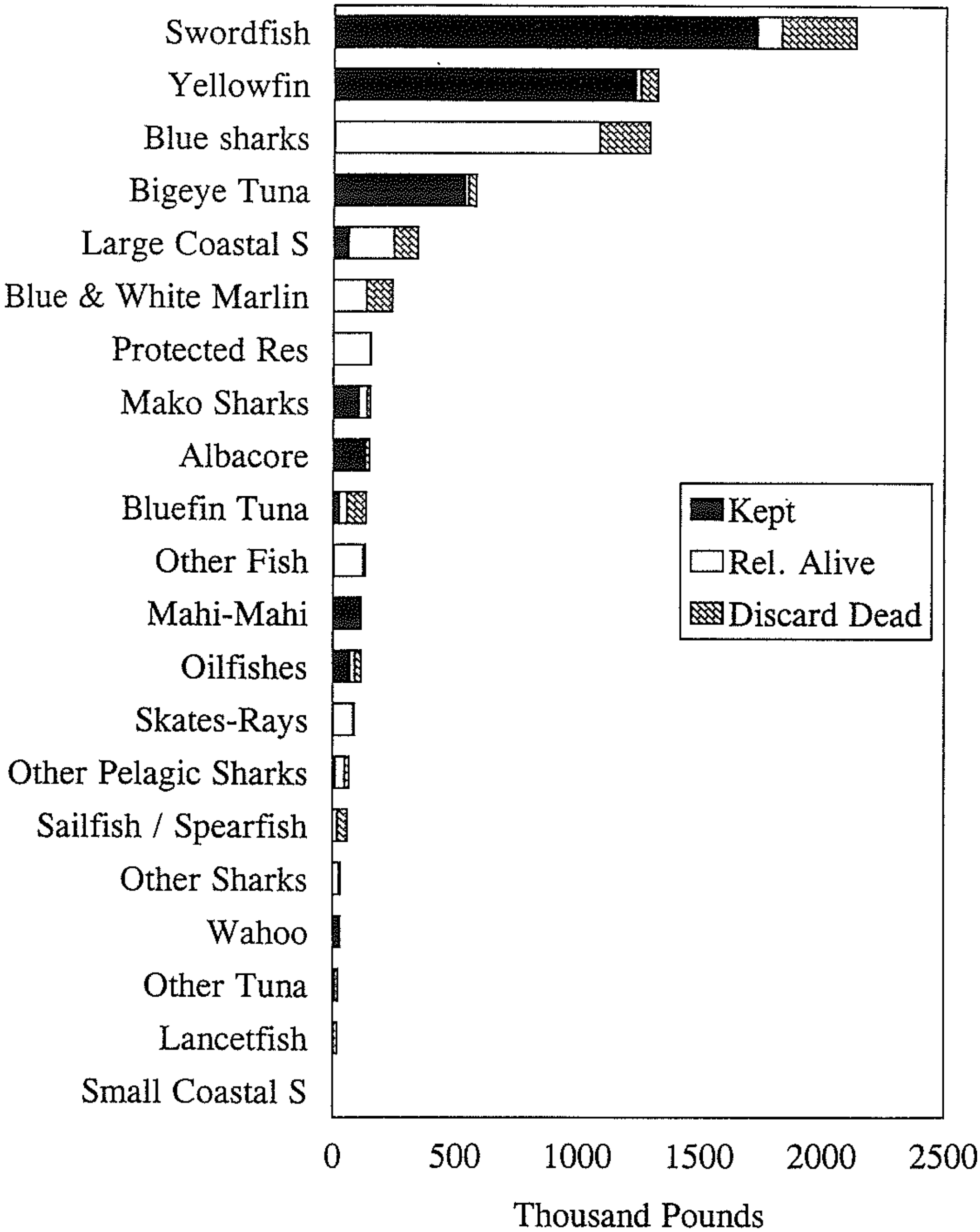


FIGURE 6. Species disposition histogram in descending weight order for 3,334 pelagic longline sets that caught 112,370 animals weighing 7,173,800 pounds.

examples. The other tuna category includes: 603 blackfin, 46 bonita, 222 little tunny, 340 skipjack, and 300 unidentified tunas. Damaged individuals account for 93% of the dead discards of these tunas. All of the other tunas, small coastal sharks, other pelagic sharks, and the wahoo individually are minor components of the catch, accounting for less than 1% of the catch in number, and combined all 4 groups account for only 2.6% of the total number caught.

Within the non-marketable category, the kept catch of skates-rays, other fish, and other sharks includes individuals kept by observers and small numbers kept for

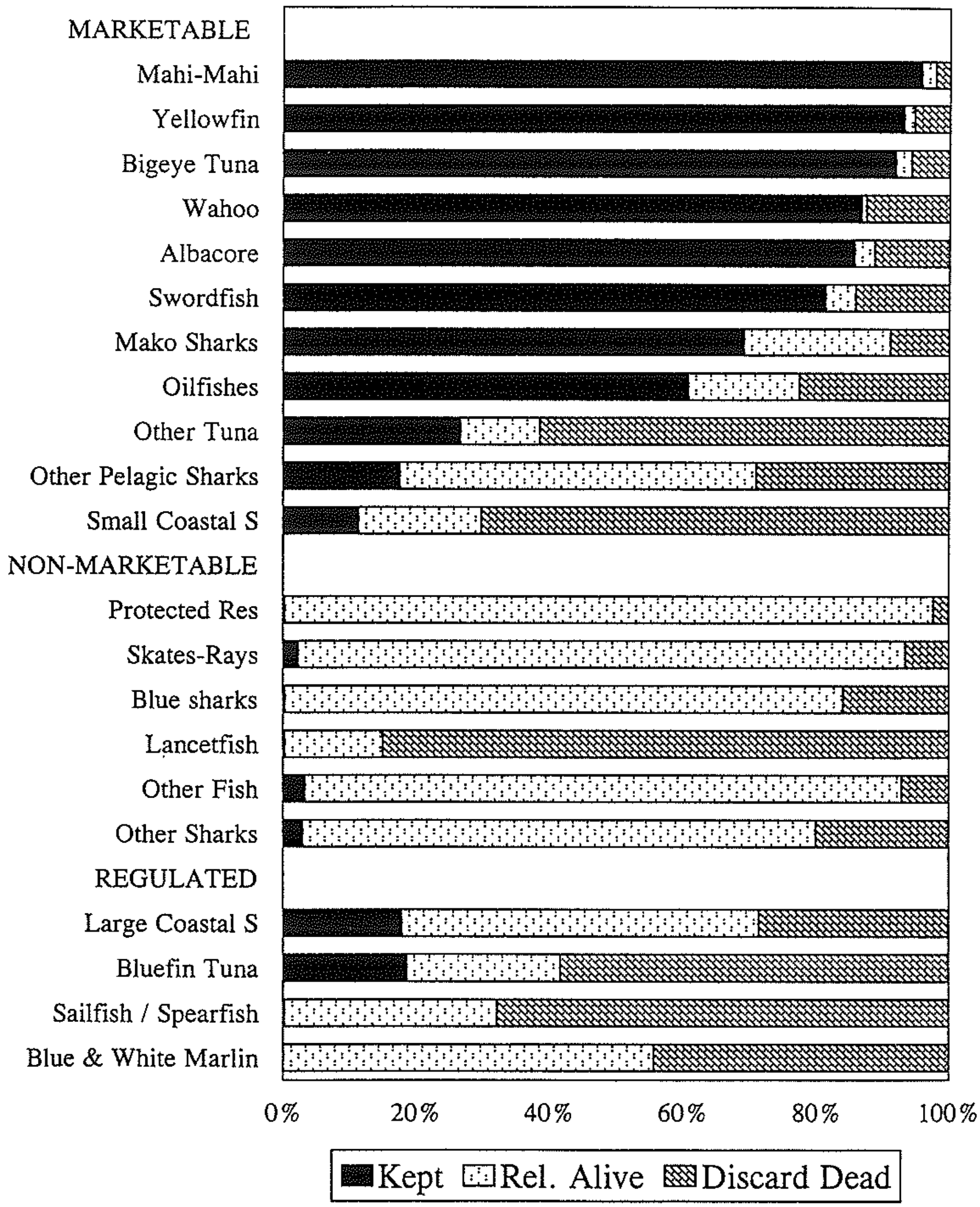


FIGURE 7. Percentage of longline catch disposition categorized by discard type of 112,370 animals; 7,173,800 pounds.

marketing. In this category, dead discards are dominated by lancetfish. Blue shark dead discards are discussed in the NED regional summary because a small number of trips with high daily gear losses accounted for a disproportionate amount (41%) of all pelagic shark dead discards. Both the protected resources (turtles, mammals, and birds) and the other shark category account for less than 1% of the total catch in number. The other fish category comprises about 2% of the number caught, although more than 25 individual species are included in that group.

The regulated species category reflects different levels of regulation ranging from trip limits and seasonal quotas for large coastal sharks and bluefin to a complete prohibition on marlin and billfish possession aboard commercial vessels. Arguably, swordfish could be included in this category given the quota and size limits that apply. However; because they are a target species and more than 80% of the harvested weight is kept and sold they are grouped within the marketable category. Dead discards of large coastal sharks partially reflect discarding that results when quotas are filled. In addition, as in the case of pelagic sharks, the flesh is considered inedible for several large coastal species, including hammerhead and tiger sharks as prime examples. Bluefin tuna are subject to very restrictive trip limits but they are a rare component of the total catch, accounting for less than 1% of the number caught.

The regulated species category with four species/species groups (large coastal sharks, bluefin, blue and white marlin, and sailfish/spearfish) account for about 30% of the total weight discarded dead. If swordfish discards (28% of the total discard weight) are added (because they are primarily caused by regulations rather than market forces), about 50% of the total weight discarded dead could be attributed to the effect of regulations as opposed to market forces. Careful consideration of how commercial fishing operations respond to trip and size limits and possible revisions of existing regulations might reduce some of this dead discarding. It is important to recall that the discarded weight is 15% of the total weight caught, and that shark and whale predation contributes significantly to the total weight that is discarded dead. The diversity of discarding patterns between species highlights the complexity of the "bycatch" issue for pelagic longline fisheries.

Targeting and daily performance statistics

It is important to emphasize that the preceding summary combines observed pelagic sets over a variety of areas and seasons, including different operating styles (targeting strategies). Previous longline studies support detailed consideration of season, area, gear and operational effects that may disproportionately affect incidentally caught species. Figure 8a and Figure 8b illustrate the significance of targeting based on when the gear was set and retrieved (hauled) during the day without regard to geographical area or season. Swordfish sets occurred between 2 p.m. and 10 p.m. with gear retrieval between 4 a.m. and 10 a.m., while tuna sets occurred from 2 a.m. until noon with retrieval between 4 p.m. and midnight. These times were subjectively chosen to capture groups of sets that appeared in clusters within a two-way frequency table of start-set and start-haul times. These figures illustrate that different operational styles using the same gear must be evaluated as related, but nonetheless distinct, fisheries.

In addition to the species composition and disposition summaries for pelagic longline effort, daily performance statistics can characterize the fishery and how it operates more thoroughly. The species composition histograms indicate that the top five species in numbers (Figure 5) account for 71% of the catch swordfish, blue shark, yellowfin tuna, mahi-mahi, and bigeye tuna). In weight, the top five species/ species groups (Figure 6) account for 79% of the total catch (swordfish, yellowfin tuna, blue sharks, bigeye tuna, and large coastal sharks). Marketable species account for four of the top five in numbers and three of the top five in weight, with the weight rankings affected by species groupings. It is also obvious from the disposition information that significant numbers, and a significant proportion of the weight caught, are released alive. This is a unique characteristic of hook-and-line based fisheries, as compared to trawl or gillnet fisheries. While live releases must be accounted for and evaluated, dead discards at least initially represent a higher priority concern. Given the geographical range of these samples and the different seasons and strategies included, a comparison against similarly summarized information from other fisheries is needed to evaluate fairly longline selectivity.

To provide indices of fishing power, effectiveness, or efficiency, different statistics can be considered. Figure 9 provides average numbers of hooks set and the associated average total daily catch in number by region for the observed pelagic longline sets. Regional average daily catches in numbers for all species range from about 20 to 42 fish, except for the NED area, which averages 72. Regional average catch rates expressed in numbers of animals caught per 1,000 hooks set (standardizing for differences in set sizes between areas) range from 3.5 to 6.9, except for the NED area, which averages 9.2. The average length of mainline set per day ranges from 17.6 to 27.8 miles in the areas adjacent to the U.S. coast, and from 33 to 36 miles in the offshore areas (TROP, WNCA, NED). These statistics indicate that generally one or two animals are caught per mile of longline set for 14 to 18 hours. For every 100 hooks set, an average 90 to 94 are retrieved without having caught anything.

In terms of daily weight production, Figure 10 provides estimates of the average weight of the daily catch that is kept, released alive, and discarded dead. In areas adjacent to the U.S. continental coast, the average weight kept per day ranged from 535 pounds (estimated total round weight) along the FEC to 1,300 pounds in the NEC area. Offshore areas including the WNCA (1,700 pounds), the NED (2,300 pounds), and the TROP (2,800 pounds) have higher average daily production, but also longer sets and trips. Conclusions about average production in the TROP area must reflect the limited number of observations. As previously mentioned, an average of 15% of the total weight caught per day is discarded dead. For the areas adjacent to the coast, this results in dead discards of between 130 and 330 pounds per day. Figure 11 provides average daily catch in numbers kept, numbers released alive, and numbers discarded dead. Because the weight of discarded animals is much smaller than those kept, the catch per day in numbers indicates higher proportions for discards. However, in general, more individual species are recorded in the species groups that are discarded while the kept groups are usually single species.

With average daily discards of four to eight individual animals from several species, discards are often on the order of only one or two individual animals per day or one individual animal every two or three days, even for the more abundant incidental species. Figure 12a and Figure 12b illustrate daily catch rates (numbers of individual animals) for some representative target and incidental species by area. This has significant statistical implications in terms of detecting the bycatch patterns that characterize the fishery.

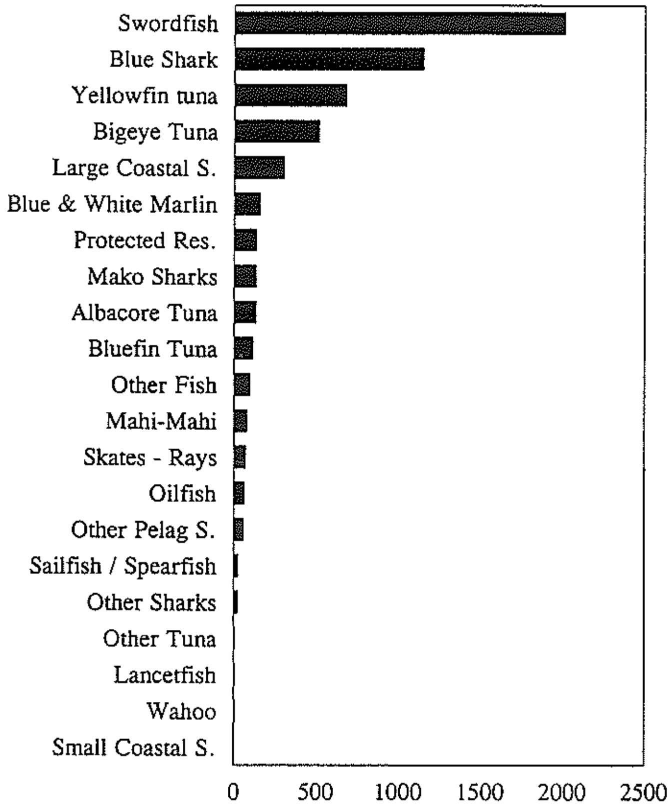


FIGURE 8a. Species composition histogram for swordfish targeted effort.

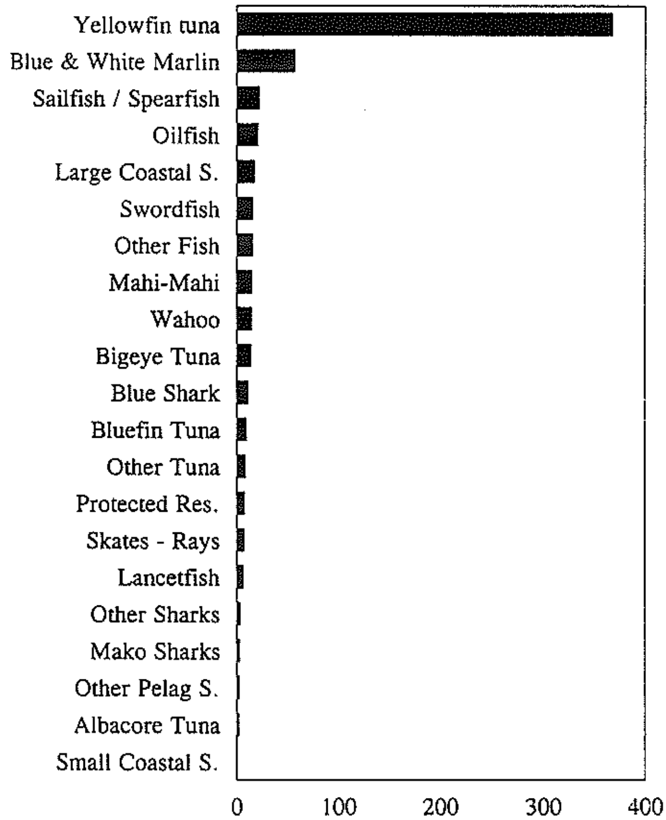
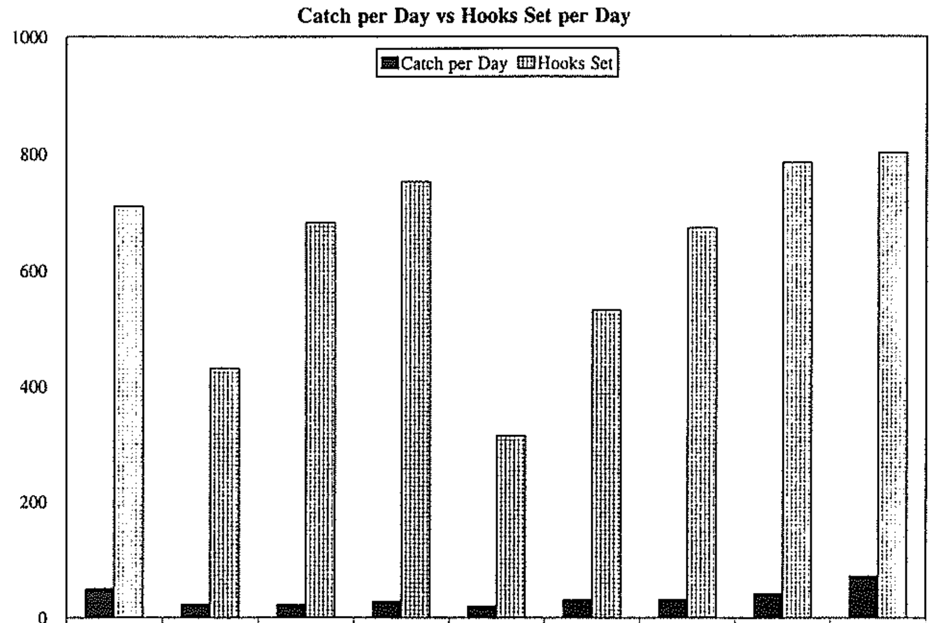
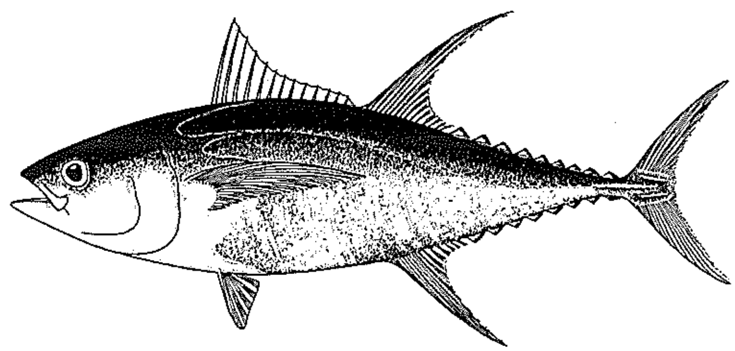


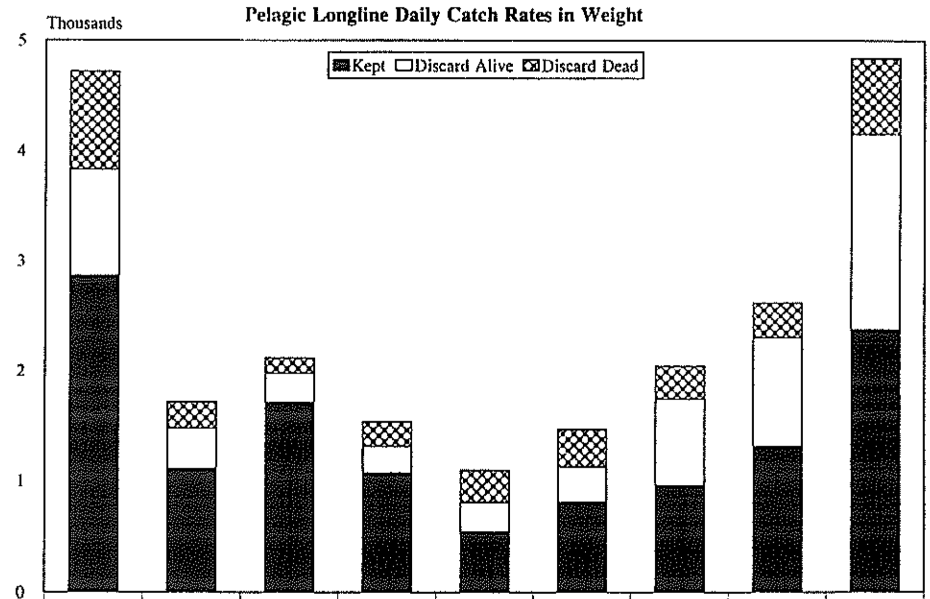
FIGURE 8b. Species composition histogram for tuna targeted effort.



	TROP	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Catch per Day	50.3	23.1	22.8	27.7	19.9	31.6	31.4	41.6	71.5
Hooks Set	711	431	683	752	314	531	673	784	801

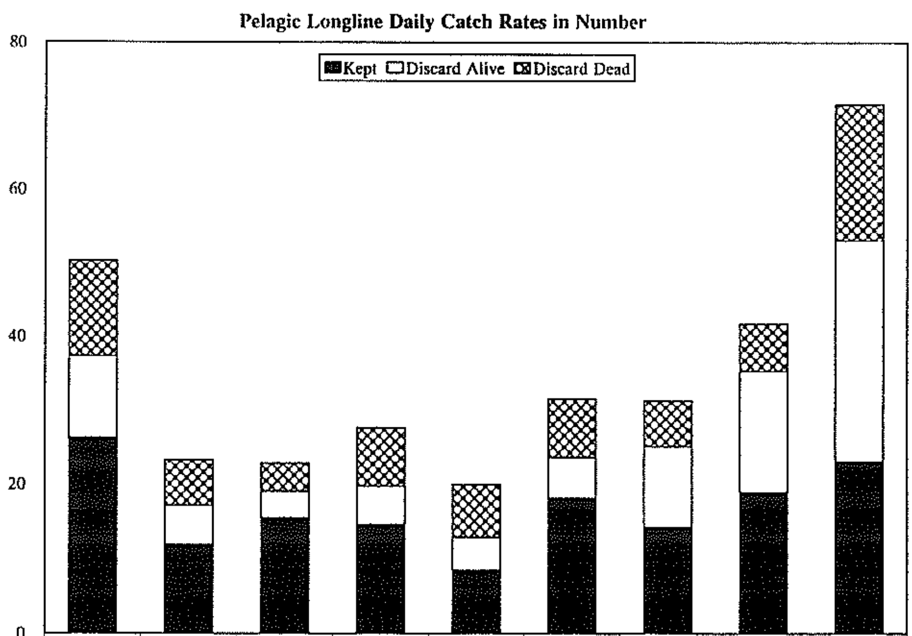
FIGURE 9. Mean number of fish caught per day and mean number of hooks set per day by area.





	TROP	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Discard Dead	0.887	0.239	0.138	0.223	0.29	0.338	0.3	0.315	0.692
Discard Alive	0.969	0.37	0.27	0.245	0.268	0.321	0.789	0.992	1.779
Kept	2.86	1.105	1.705	1.064	0.535	0.802	0.95	1.307	2.369

FIGURE 10. Mean catch per day in thousands of pounds whole weight by disposition category and area.



	EQTROP	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Discard Dead	13	6.1	3.8	7.9	7.1	8	6.2	6.4	18.4
Discard Alive	11.1	5.3	3.6	5.2	4.4	5.5	10.9	16.4	30.1
Kept	26.2	11.8	15.4	14.5	8.4	18.1	14.2	18.9	23

FIGURE 11. Mean catch per day in numbers by disposition category and area.

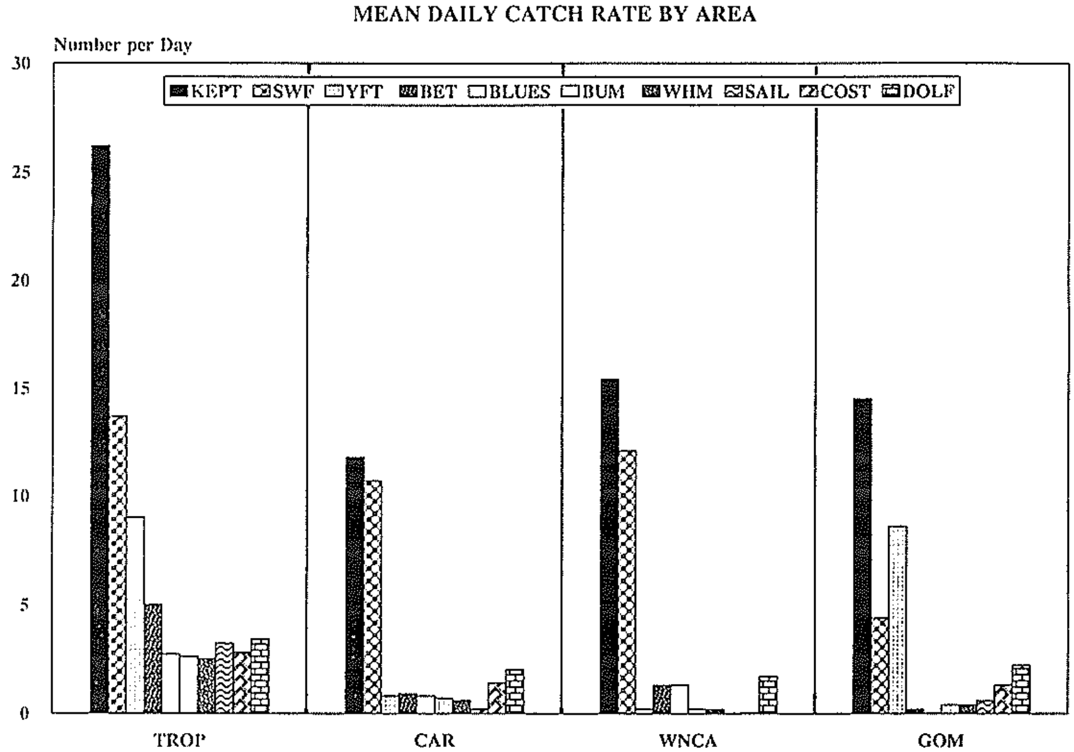


FIGURE 12a. Mean number caught per day by area for selected species. Kept is total kept catch. SWF is swordfish, YFT is yellowfin tuna, BET is bigeye tuna, BLUES is blue sharks, BUM is blue marlin, WHM is white marlin, SAIL is sailfish, COST is all coastal sharks, and DOLF is dolphin fish (Mahi-Mahi).

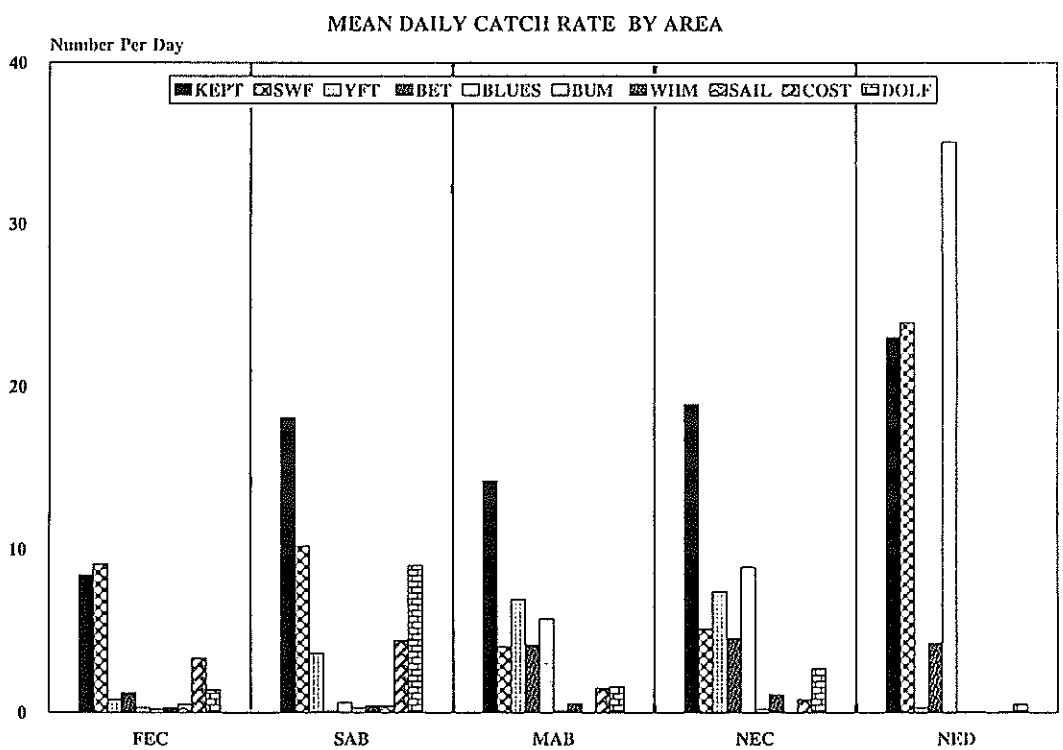


FIGURE 12b. Mean number caught per day by area for selected species.

Figure 13 plots the proportion of observed sets that caught from zero to six or more individual animals for selected target and bycatch species. Of the 13 species listed, seven had zero catch rates 75% to 96% of the time, including bluefin tuna, blue and white marlin, sailfish, and several species of sharks. These species are of particular concern as "bycatch issues," despite the fact that high interaction rates of more than two of any of these species caught on a single day are very rare. High proportions of zero catches make it very difficult to identify statistically the gear and operating characteristics that are correlated with these catch rates and the geographical and environmental variables that presumably influence these species distributions.

Subsequent analyses demonstrate that catch rates for a number of these incidental species are clustered and specific circumstances within regions and seasons contribute inordinately to the number of these species caught. Identifying and describing these conditions provides an opportunity to assist captains in avoiding these situations. The wide geographic distribution of many of these species, combined with the fact that many are rarely caught with pelagic longline gear, results in a subsequent focus on specific region and season combinations. Regional/seasonal effort patterns may be the most efficient fleet management option to use for developing gear- and operational- based regulations intended to minimize bycatch.

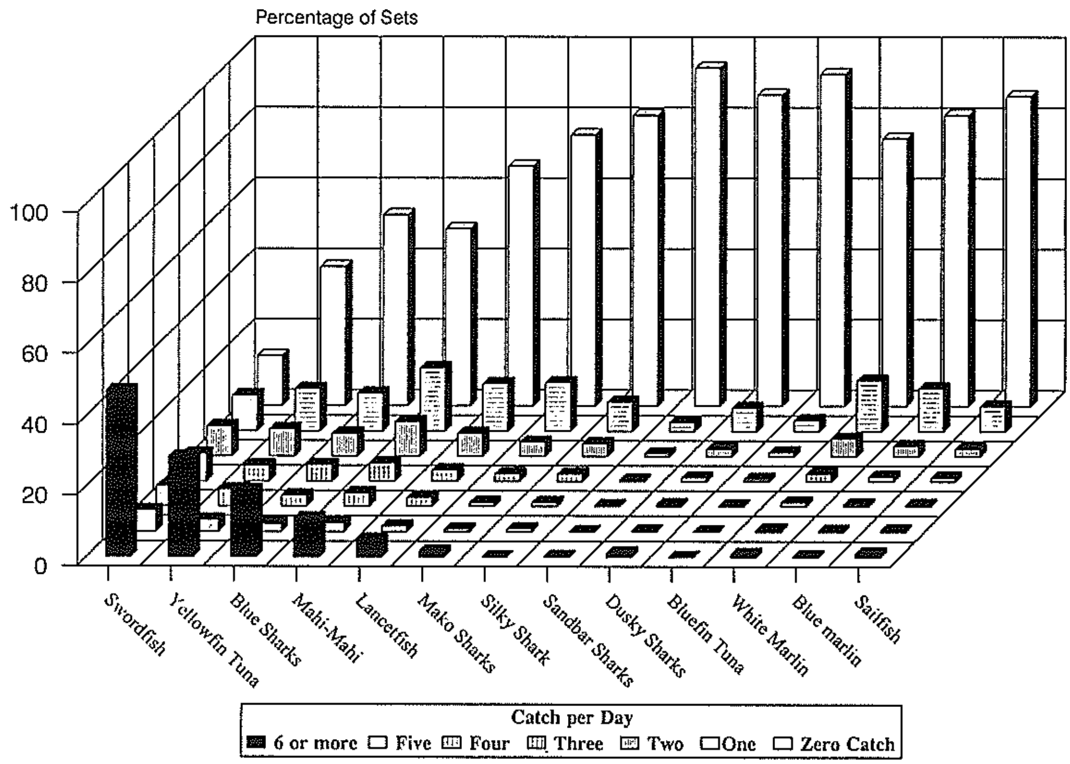
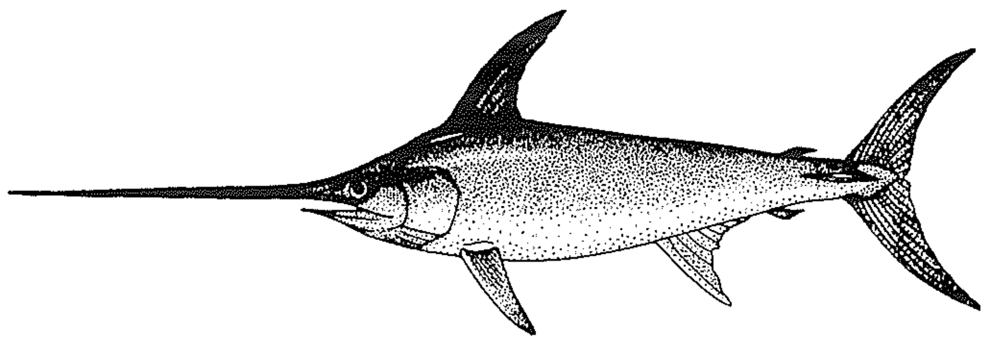
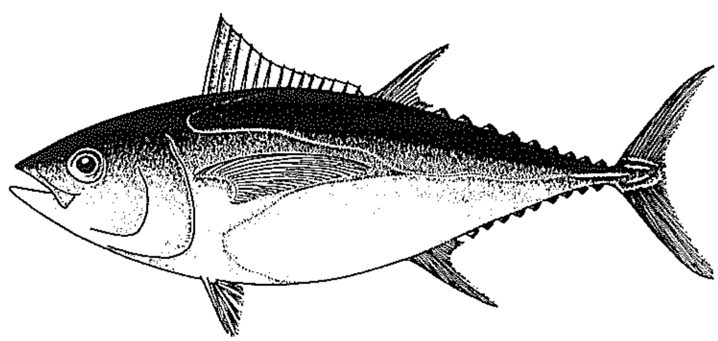


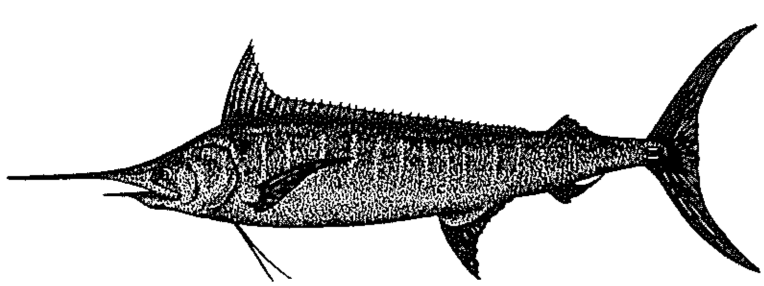
FIGURE 13. Proportions of observed sets with daily catch rates of from zero to six or more for selected target and bycatch species based on 3,334 observed pelagic longline sets.

REGIONAL CATCH AND DISCARD PATTERNS

The following sections present regional catch composition and disposition information progressing roughly south to north beginning with the southern offshore areas, through the Gulf of Mexico and along the east coast, and ending in the NED area. Comments are provided on differences and similarities between areas, especially adjacent areas, and on the different gear and operational styles of fishing within each area.

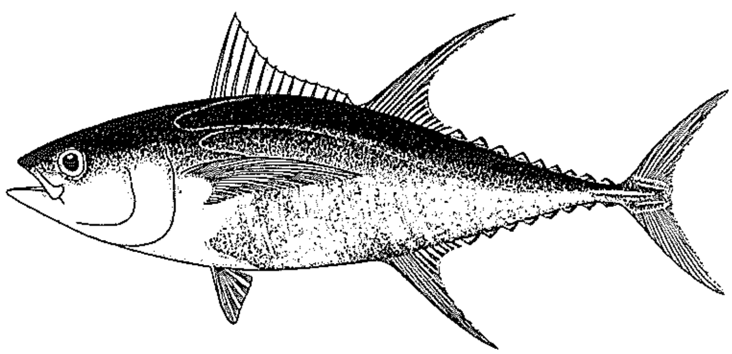






TROPICAL (TROP)

Data from the TROP area are extremely limited in numbers of observed sets (n = 52), trips (four), and months sampled (February, May, and August all in the same year). These trips were apparently exploratory efforts to evaluate the feasibility of U.S. vessels operating in this area, rather than following the fish northward with warming water temperatures. Figure 14 presents the catch disposition histogram in descending order of weight for sets in the TROP area. Effort targeted both yellowfin tuna and swordfish. All sets occurred in water depths beyond 1,000 meters and were rigged to fish shallow with only three or four hooks set between each float. In terms of when the gear was set and retrieved (described earlier), about 32 sets fit the swordfish daily pattern and 17 fit the tuna pattern. Average swordfish catch rates were comparable to those recorded for similar vessels operating in the NED area and were slightly higher than those for the WNCA. Average yellowfin catch rates were comparable to those recorded for the GOM and MAB areas, while Bigeye Tuna catch rates were higher than those recorded for the MAB. Given the limited number of observations in this area it is very likely that these slightly higher catch rates are not statistically significant. The 52 observed sets (1.6% of the total) account for a disproportionate share (11.5%) of the total marlin and sailfish/spearfish catch, reflecting some of the highest catch rates observed for these species.



TROPICAL (TROP) CATCH DISPOSITION

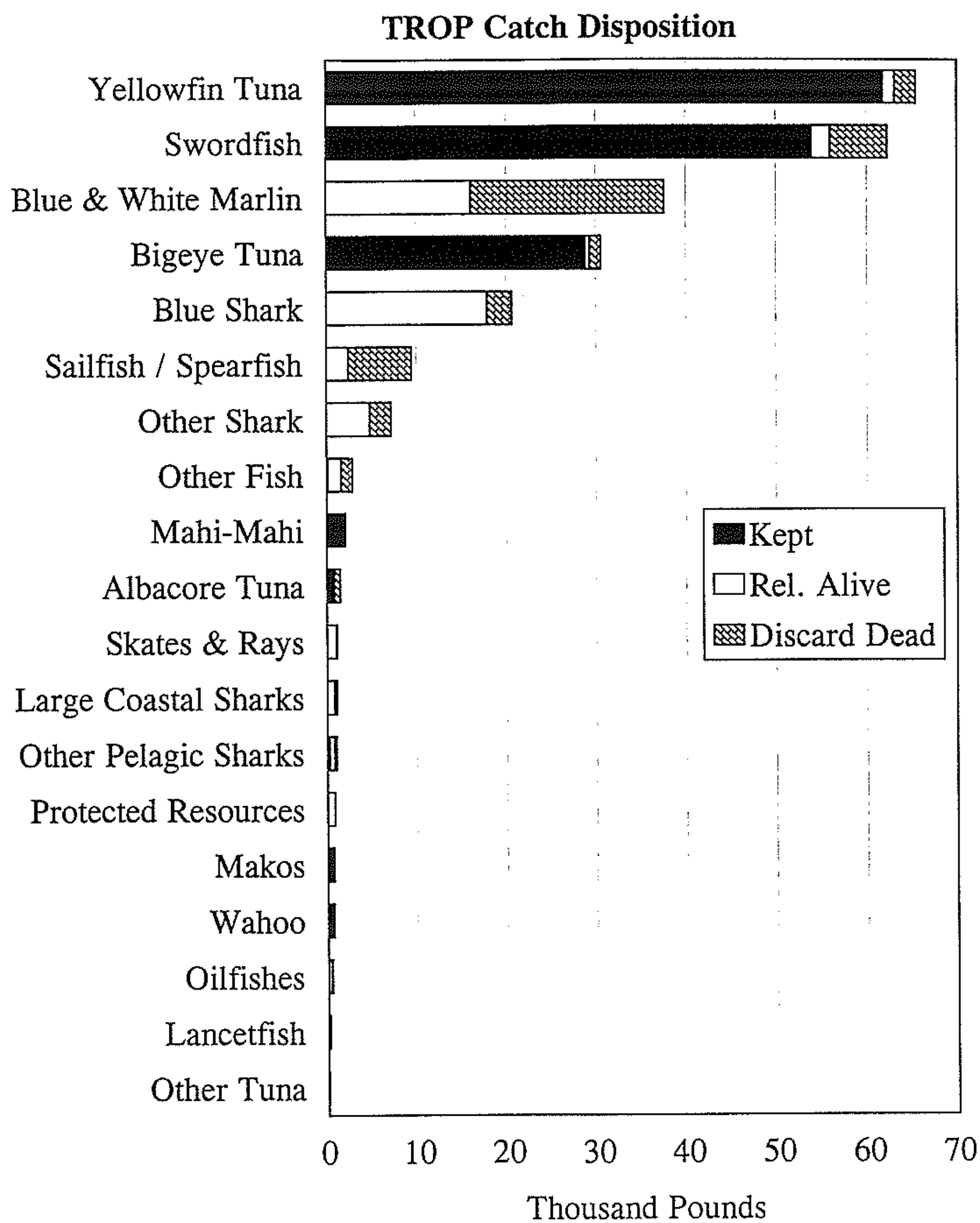
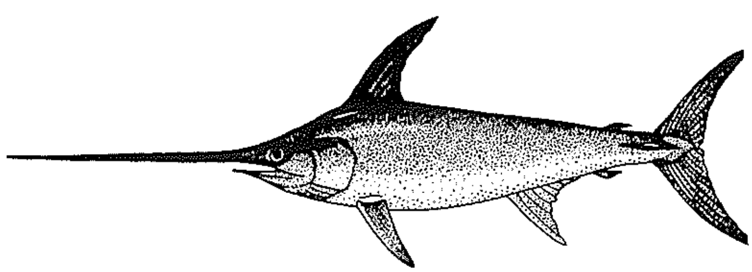


FIGURE 14. Catch disposition histogram in descending order of weight for sets in the TROP area.

CARIBBEAN (CAR)

The Caribbean area (CAR) had the second smallest number of observations recorded for the nine areas sampled (149 sets), and 61% of these were during the first quarter of the year. Additionally, almost all of the observations were confined to the 1^0 squares associated with the Yucatan, Windward, and Mona passages between the islands. Figure 15 presents the catch disposition histogram in descending order of weight for sets in the CAR area. Swordfish was the obvious target species, and the time periods for setting and hauling the gear reflect this with almost all sets beginning after 5 p.m. with retrieval starting after 6 a.m. One set occurred in water depths less than 500 meters, while the others were in depths greater than 1,000 meters. Nominal swordfish catch rates differ by 1.5 swordfish per set for sets equal or deeper than 2,000 meters (11.3) versus those from 1,000 meters to 1,999 meters (9.7). For the catenary rig (number of hooks set between floats), 84% were set with three or four hooks and there was almost no difference in swordfish catch rates. Nine sets were rigged with five hooks between floats and the average swordfish catch rate was about double that for the three-and-four-hook rigs. No white marlin or sailfish were observed on the five-hook rigs. Although the observations are limited, experimenting with deeper gear rigs (five hooks or more) and attempting to set in depths greater than 2,000 meters may increase swordfish catch rates while reducing white marlin and sailfish catch rates. Average sizes for swordfish, bigeye, and albacore tuna are also slightly larger in depths greater than 2,000 meters.



CARIBBEAN (CAR) CATCH DISPOSITION

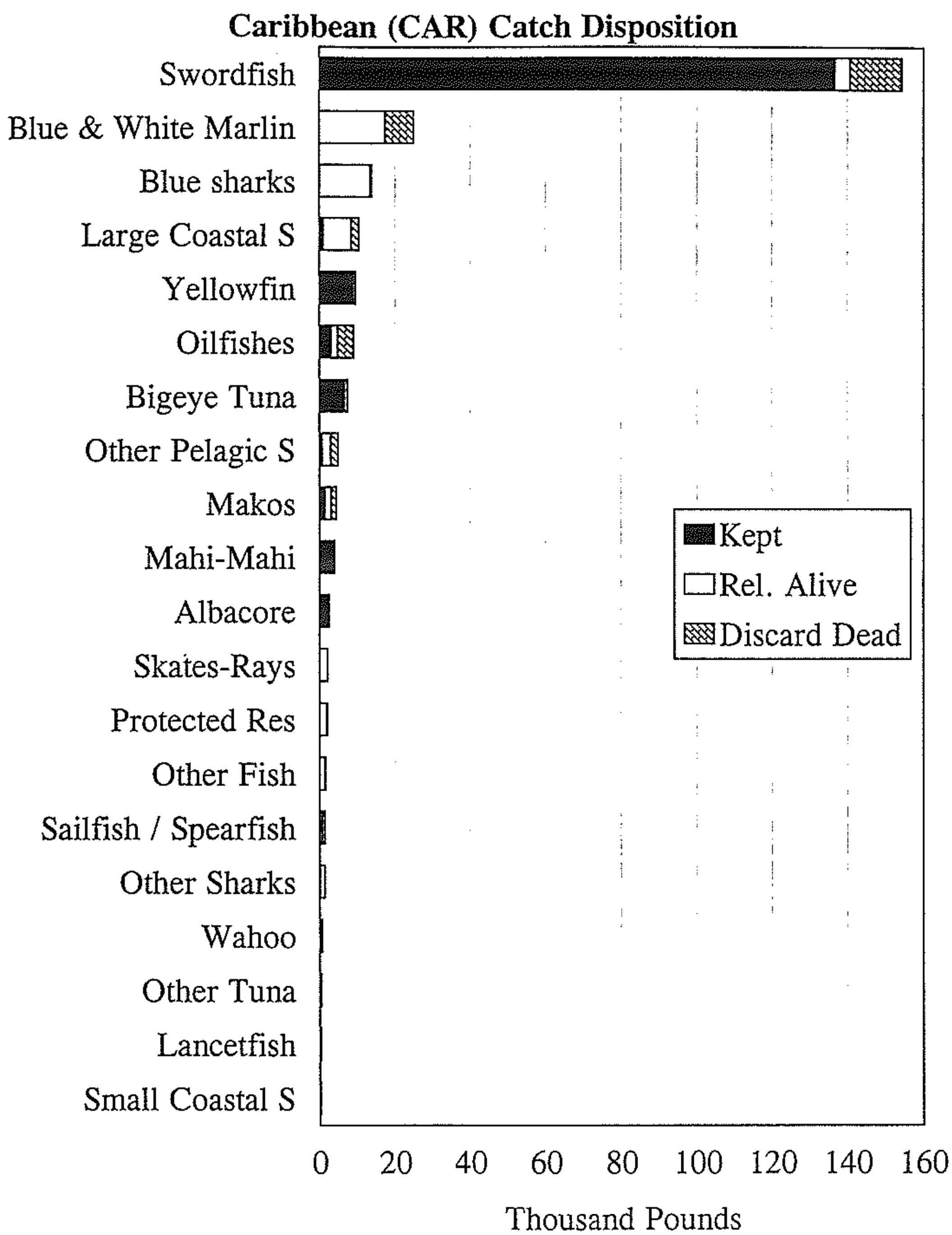
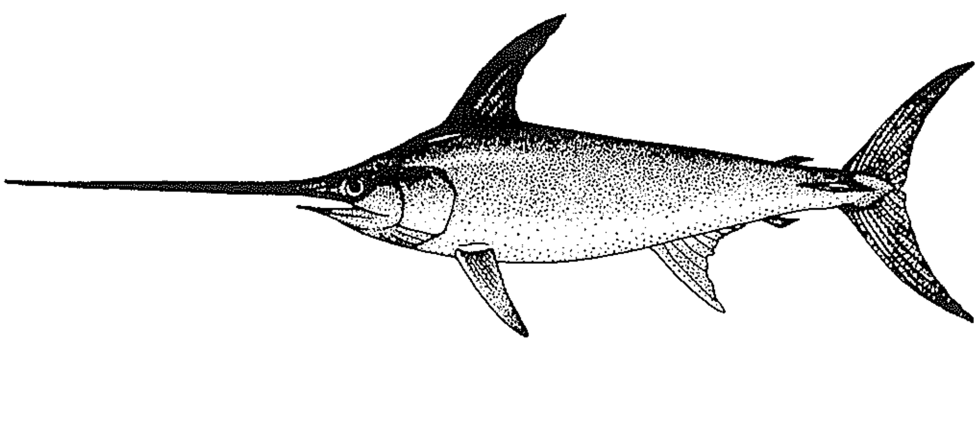


FIGURE 15.Catch disposition histogram in descending order of weight for sets in the CAR area.

WESTERN NORTH CENTRAL ATLANTIC (WNCA)

The Western North Central Atlantic area (WNCA) had 224 observed sets, with 90 observed during the first quarter. Figure 16 presents the catch disposition histogram in descending order of weight for sets in the WNCA area. As in the CAR area, swordfish was the obvious target species as evidenced by the time periods for setting and hauling the gear. Only three sets were observed in depths less than 2,000 meters. In terms of catenary rigs (hooks between floats), 54% were set with three hooks, 16% with two hooks, and 30% with four hooks. Average swordfish catch rates were nearly identical for the two-and-three-hook rigs, (11.5 and 11.7, respectively), whereas the four-hook rig catch rate averaged slightly higher (13.2 swordfish). In this area, blue and white marlin catch rates were lower than in the CAR and TROP areas, and a total of only three sailfish were observed.



WESTERN NORTH ATLANTIC (WNCA) CATCH DISPOSITION

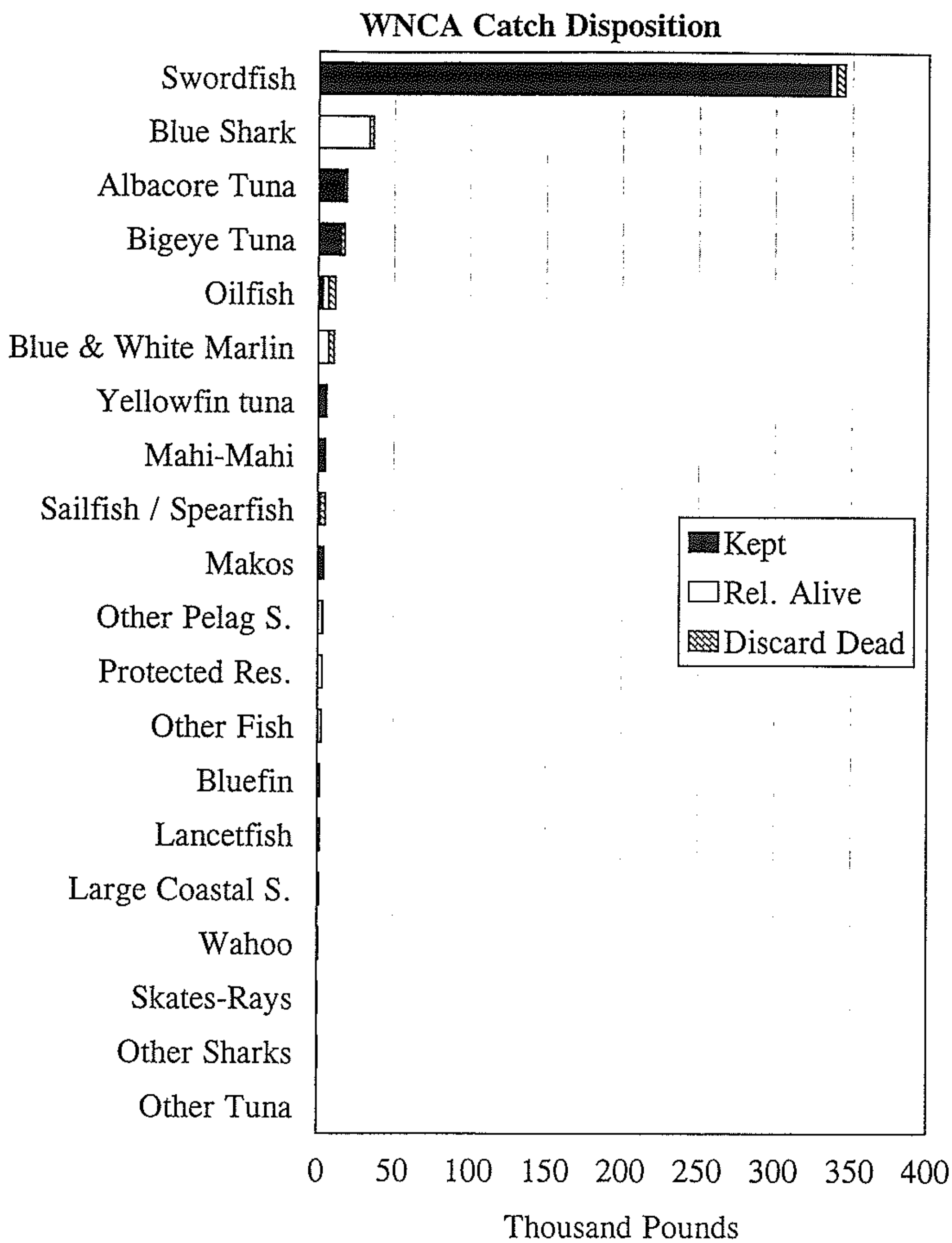


FIGURE 16. Catch disposition histogram in descending order of weight for sets in the WNCA area.

GULF OF MEXICO (GOM)

The Gulf of Mexico (GOM) was the most heavily sampled area (n=954) with quarterly samples ranging from 187 to 269 observations. Figure 17 presents the catch disposition histogram in descending order of weight for sets in the GOM area. In contrast to the CAR and WNCA areas, yellowfin tuna is the dominant target species accounting for 51% of the total weight caught with swordfish accounting for an additional 15% of the total weight caught. Swordfish targeting is obviously occurring in the GOM, where about 42% of the sets correspond to the swordfish targeting time pattern mentioned earlier.

The observed sets in the GOM include a greater diversity of gear and operational characteristics than were observed in other regions. Set and haul times occur throughout the day. The number of hooks set between floats range from two to eight, and 12% of the sets were in depths shallower than 1,000 meters. This provides an opportunity to compare water depths and catenary rigs (four hooks or less between floats versus five or more hooks) in terms of target and incidental catch rates. Additionally, gear tending, live bait use, and circle hooks are represented in this area by numbers of observed sets that are far greater than in all other areas combined. While this presents opportunities to investigate gear and operational styles, once three or more characteristics are combined, such as target style (swordfish versus tuna), bottom depth strata, and bait style (tending, dead, or live), the limited numbers of observations become a constraint. Under these conditions, confounding complicates the analysis of the effect a specific variable has on a specific specie's catch rate.

With respect to fishing depth, 115 sets were shallower than 1,000 meters and 837 sets in depths greater than or equal to 1,000 meters. Table V lists the nominal catch per day for sets that were made in water shallower and greater than or equal to 1,000m for swordfish, yellowfin tuna, all marlin and billfish, blue and white marlin, sailfish, large coastal sharks and other finfish.

TABLE V. Nominal catch per day for GOM sets by water depth.

SPECIES	Catch per Day Depths < 1,000 meters	Catch per Day Depths >=1,000 meters
Swordfish	11.7	3.5
Yellowfin Tuna	5.1	9.0
All Marlin & Billfish	3.0	1.3
Blue Marlin	0.3	0.4
White Marlin	0.7	0.3
Sailfish	1.8	0.5
Coastal Sharks	4.1	0.9
Other Finfish	6.3	9.1
Mahi-Mahi	2.2	2.2

GULF OF MEXICO (GOM) CATCH DISPOSITION

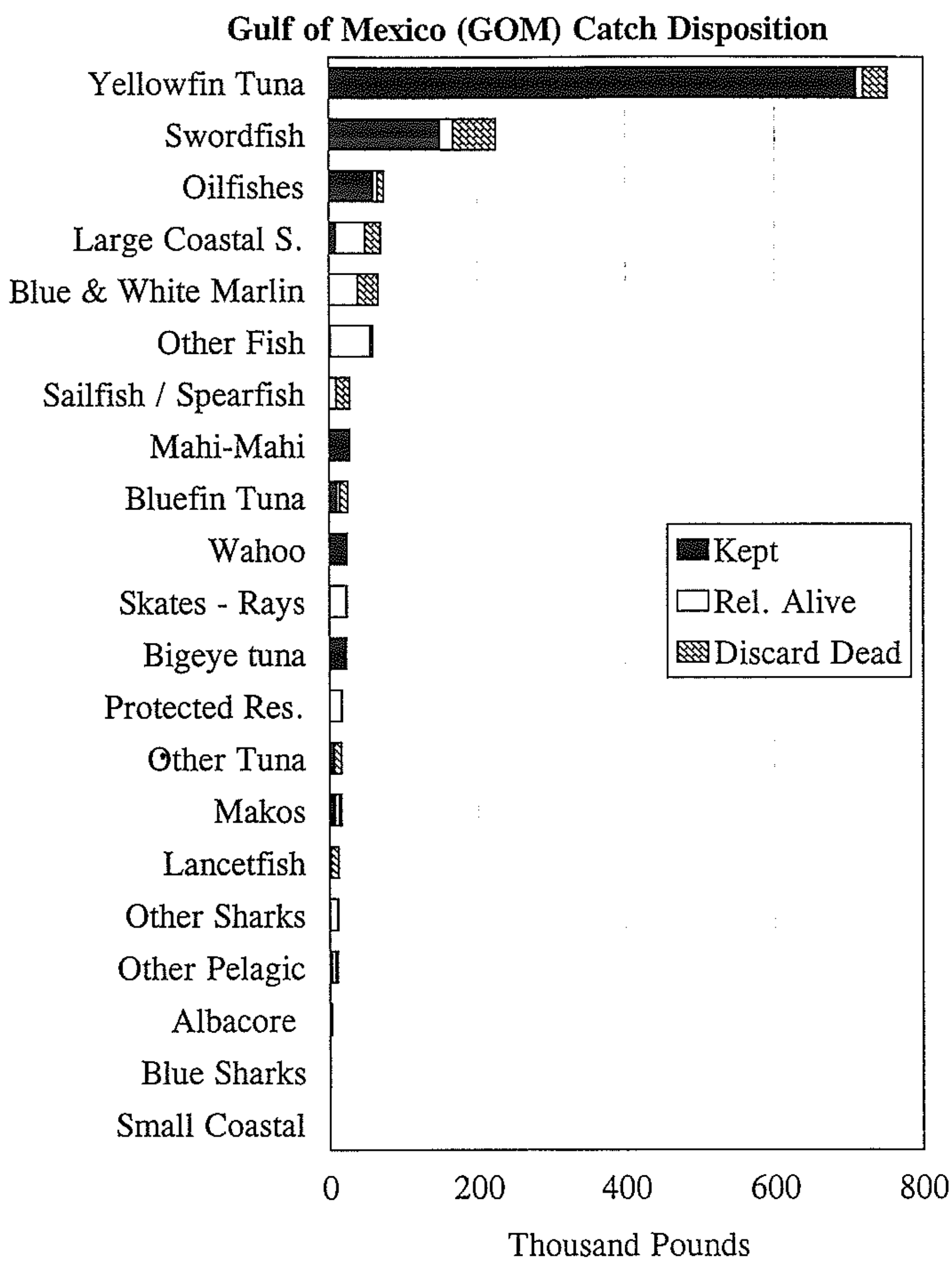


FIGURE 17. Catch disposition histogram in descending order of weight for sets in the GOM area.

Swordfish, all marlin and billfish combined, white marlin, sailfish, and large coastal sharks had higher daily catch rates (numbers) where depths were less than 1,000 meters. Yellowfin tuna and other finfish had higher daily catch rates where depths were greater than or equal to 1,000 meters, while blue marlin and mahi-mahi had virtually the same catch rates. These catch rates are consistent with the fact that directed swordfish effort focuses on the edge of the continental shelf and has a larger proportional catch of coastal shark species, whereas yellowfin effort has a lower coastal shark bycatch, but catches greater numbers of other finfish, and lancetfish in particular. Swordfish targeted effort over both shallow and deep depths had average marlin and billfish catch rates that were significantly lower, frequently by 50% to 70%, than those observed for tuna targeted effort

Sets made over shallower depths have higher sailfish and white marlin CPUEs (mean numbers caught per 1,000 hooks). Additionally, for any depth or targeting pattern, rigs with shallower catenaries (smaller numbers of hooks between floats) generally have higher sailfish and white marlin CPUEs, although the latter conclusion must be tempered by the recognition that observations are limited after three or more factors are combined. For yellowfin tuna, sets in deeper water have higher CPUEs, and deeper catenaries within shallower depths also have higher yellowfin CPUEs. Swordfish catch rates are higher with shallower catenaries for swordfish and miscellaneous targeting styles, whereas swordfish catch rates are slightly higher with deeper catenaries under the tuna targeting time pattern.

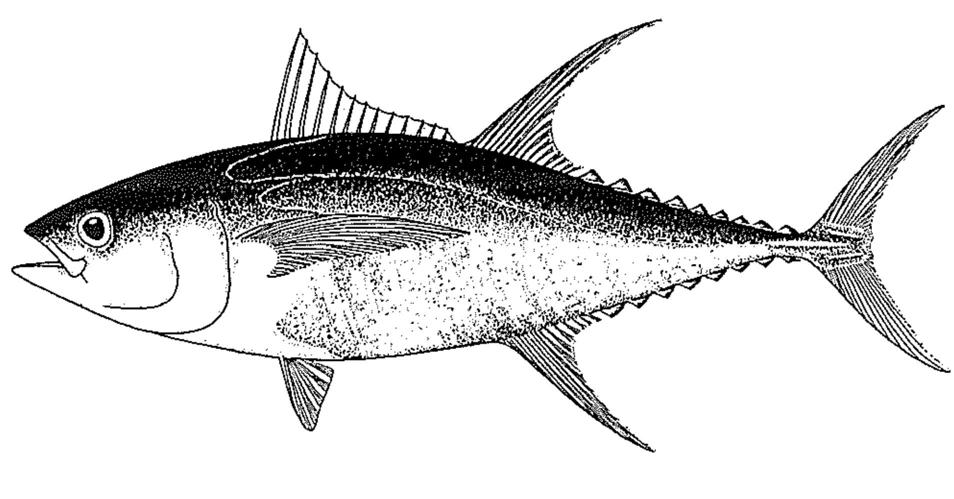
Of all the areas observed, only the GOM has a large number of sets that used live bait (n=210), including the only observations of gear tending (n=47). Initially, catch rates (numbers per 1,000 hooks) were compared between sets using live bait and those using dead baits without accounting for the fact that all tended sets used live bait. The ratio of the live bait CPUE to the dead bait CPUE provides a measure of the relatively higher effectiveness of live baits at catching specific species when the value exceeds 1.0, and it indicates that dead bait is more effective when the value is less than 1.0. The ratios were as follows:

Sailfish	2.9
White marlin	2.2
Blue marlin	1.6
Yellowfin tuna	1.4
Mahi-mahi	1.3
Total catch kept	1.1
Swordfish.	0.6

While live bait sets in the Gulf of Mexico account for only 6.3% of the total sets observed (n=3,334), they accounted for approximately 26% of the sailfish, 13% of the blue marlin, and 10% of the white marlin. Overall, live bait sets result in a CPUE (number per 1,000 hooks) for all the species that are kept that is 13% higher than dead bait sets, reflecting a balance between the reduced efficiency of live baits for swordfish and the higher efficiency for yellowfin tuna and mahi-mahi. All three species are numerically dominant in the retained GOM catch. Clearly, live bait sets had significantly higher average CPUEs for sailfish, white marlin, blue marlin, and yellowfin tuna. The combined effect of tending and the use of live bait resulted in some of the highest average CPUEs for blue marlin and yellowfin, whereas the pattern was less clear for white marlin and sailfish.

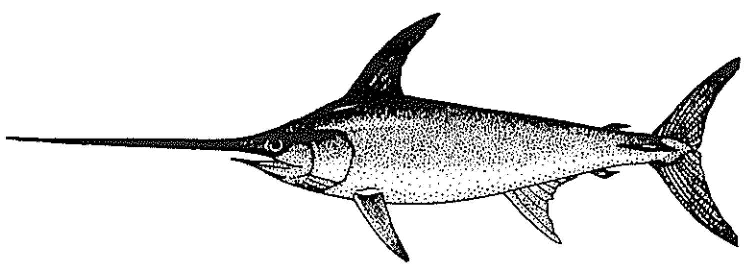
Given the fact that the fishery in the Gulf of Mexico is focused on yellowfin tuna, the implications of setting patterns and baiting practices are critical. The average yellowfin CPUEs for dead and live bait, once tended sets are deleted from the live bait category, were nearly identical for the miscellaneous setting pattern (dead 13.7 - live 13.1), slightly lower for the swordfish setting pattern (dead 5.4 - live 6.3), but higher for the tuna setting style (dead 16.2 - live 13.7). Live bait, without tending, produces much higher marlin and billfish CPUEs, with no gain in yellowfin CPUE. This is an extremely important result, because it indicates that for yellowfin tuna, captains would do better in terms of the target (yellowfin) catch per 1,000 hooks with dead bait rather than live bait, if they ensure that their tuna sets fit the tuna setting pattern. Captains might be able to enhance yellowfin catch rates by avoiding depths shallower than 1,000 meters. It also appears that setting deeper catenaries would reduce billfish bycatch with little impact on the yellowfin CPUE. The latter might result in a reduction of one or two yellowfin per 1,000 hooks from CPUEs of 16 or 17 to CPUEs of 14 or 15. Initial analyses of yellowfin catch rates based on setting styles, bait types, and whether circle or J-hooks were used, indicate that circle hooks would increase dead bait yellowfin CPUEs by about one or two yellowfin per 1,000 hooks.

Captains fishing in the GOM could significantly reduce marlin and billfish catch rates by abandoning gear tending, live bait, and fishing inside of 1,000 meters depth while targeting yellowfin (daytime target period). They could maintain their fishing operations with similar or higher yellowfin catch rates by fishing in depths greater than 1,000 meters, using dead bait and circle hooks, and setting five or more hooks between floats. Nighttime swordfish effort already has very low marlin and billfish catch rates, but swordfish discards would be reduced if effort moved from between 200 and 499 meters to depths greater than 500 meters. These actions could practically address the concerns of billfish sportfishermen while maintaining target catch rates at levels that should be economically viable.



FLORIDA EAST COAST (FEC)

The Florida East Coast (FEC) area had 321 observed sets spread fairly evenly throughout the year. Figure 18 presents the catch disposition histogram in descending order of weight for sets in the FEC area. Swordfish was the clear target with 95% of the sets fitting the swordfish daily setting and hauling pattern. With respect to the water depths for observed sets, 4% were in depths shallower than 200 meters, 85% were between 200 meters and 999 meters, and 11% were in depths of 1,000 meters or greater. The smaller proportion of observed sets beyond 1,000 meters probably reflects the international fishery boundary between the U.S. and the Bahamas. While swordfish catch rates averaged 41 swordfish per 1,000 hooks in depths between 200 and 499 meters, versus 26 between 500 and 999 meters, discard CPUEs (number per 1,000 hooks) were higher over shallower depths, 27.8 from 200 to 499 meters versus 14.8 from 500 to 1,000 meters. The shallower depths (<500 meters) produced only two more kept swordfish per 1,000 hooks with a doubling of the number discarded. Average sizes were also larger for the kept swordfish in depths between 500 and 999 meters so the difference in mean weight kept between depths < 500 meters and those between 500 and 999 meters, was only about 3% to 5% less. Nominal daily catch rates for sailfish and coastal sharks were also higher between 200 and 499 meters. Silky and dusky sharks in particular seemed more abundant in depths less than 500 meters. In terms of the catenary rigs (hooks between floats), the pattern was very similar to the other swordfish areas — CAR & WNCA — where shallow rigs predominated: 63% less than four hooks, 23% with four hooks, and 14% with five or more hooks. Shallow catenary rigs are consistent with a swordfish targeting strategy. Although swordfish CPUEs are generally higher for the shallower rigs, the CPUE for the kept catch is very similar, indicating that shallower rigs, especially in shallower depths, may have a much higher discard rate.



FLORIDA EAST COAST (FEC) CATCH DISPOSITION

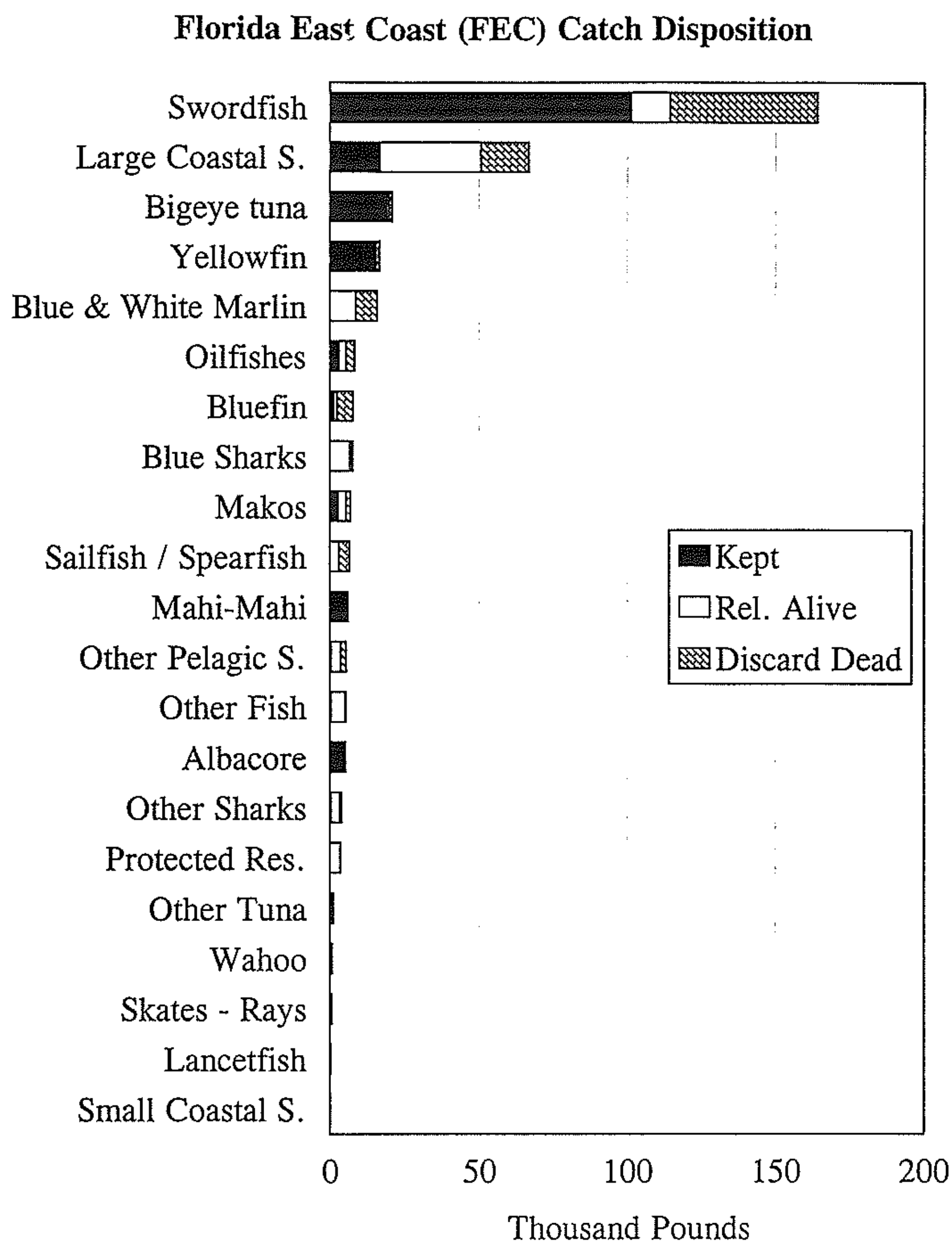
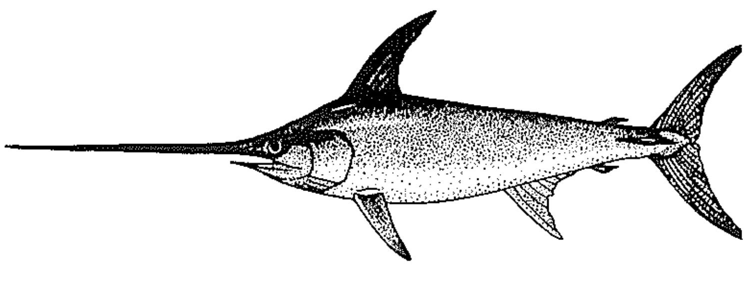


FIGURE 18. The catch disposition histogram in descending order of weight for sets in the FEC area.

SOUTH ATLANTIC BIGHT (SAB)

The South Atlantic Bight (SAB) area had 341 observed sets, with 49% recorded in the second quarter and 25% in the third quarter. Figure 19 presents the catch disposition histogram in descending order of weight for sets in the SAB area. Swordfish was the clear target species with 93% of the sets fitting the swordfish daily setting and hauling pattern. With respect to the water depths, 85% of the observed sets were between 200 and 999 meters, and 12% were in depths of 1,000 meters or more. Swordfish catch and discard rates (CPUEs) were 23.2 and 12.8, respectively between 200 and 499 meters compared to 27.7 and 15.1 between 500 and 999 meters. As in other areas, swordfish CPUEs were the highest in the 200 to 999 meter depth range and with shallow catenary rigs (four hooks or less). Coastal shark catch rates were 7.2 in depths less than 200 meters (n=10), 5.3 between 200 and 499 meters, 3.9 between 500 and 999 meters, and 2.5 at depths greater than 1,000 meters (n=41). Catenary rigs (hooks between floats) were more variable than in the FEC: 32% less than four hooks, 28% with four hooks, 12% with five hooks, and 28% with six hooks, or more. Most of the sailfish and blue marlin were caught between 200 and 999 meters where most observations occurred, and shallow rigs within those depths had higher CPUEs. In contrast, CPUEs for yellowfin tuna were higher for deeper catenaries.



SOUTH ATLANTIC BIGHT CATCH DISPOSITION

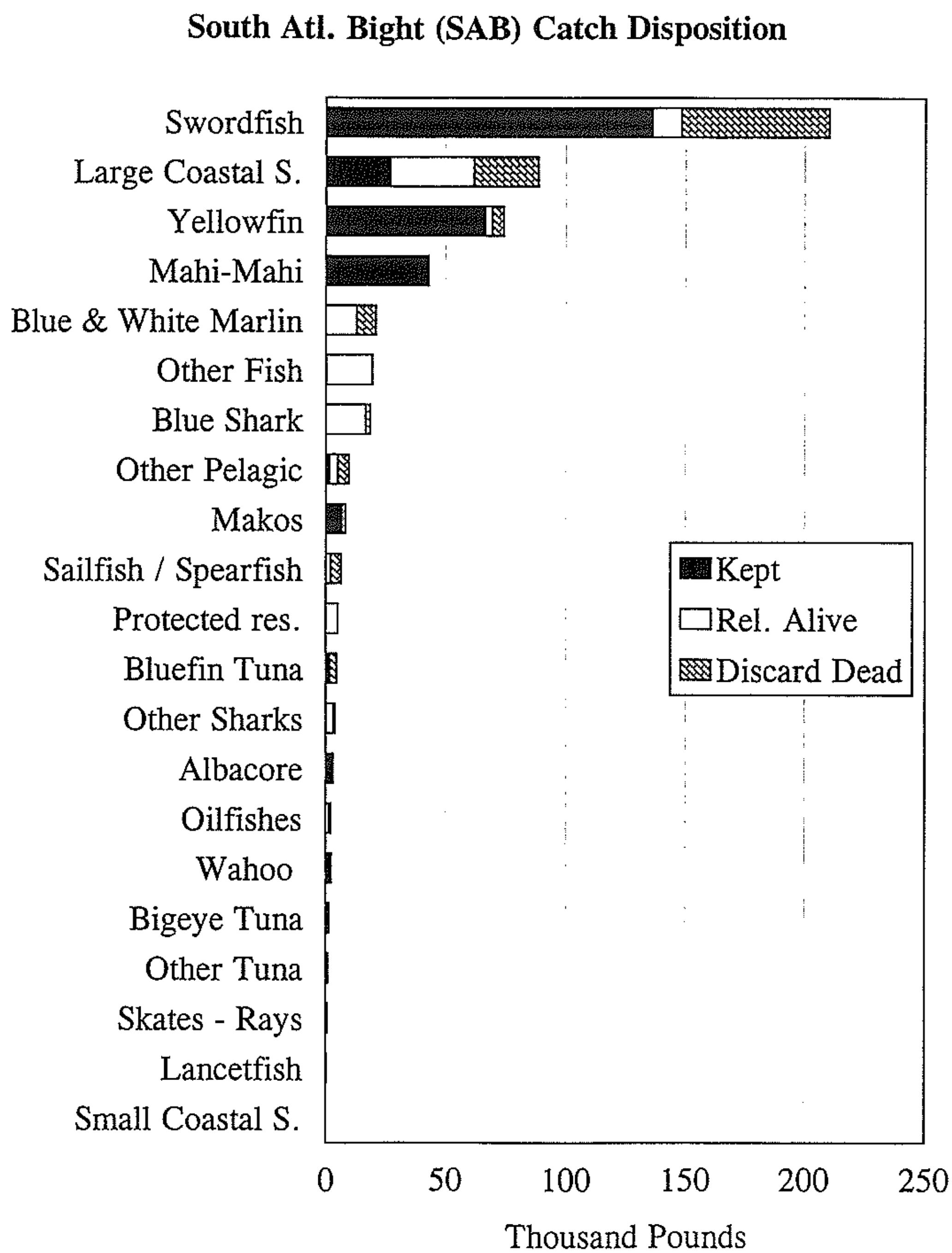


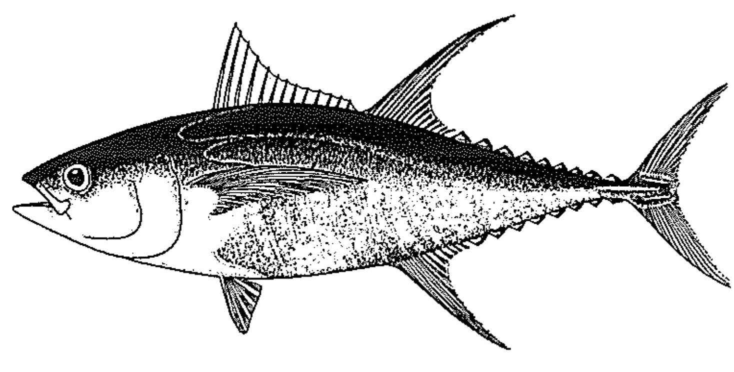
FIGURE 19. The catch disposition histogram in descending order of weight for sets in the SAB area.

MID-ATLANTIC BIGHT (MAB)

The Mid-Atlantic Bight area had the second largest number of observed sets (n=617). Sampling was particularly heavy in the third and fourth quarters, which accounted for 75% of the total. Figure 20 presents the catch disposition histogram in descending order of weight for sets in the MAB area. Although 88% of the sets fit the swordfish daily setting and hauling pattern, swordfish was the fourth ranked species by weight after blue sharks, yellowfin, and bigeye tuna. It appears that tuna targeting strategies north of Cape Hatteras were not as closely tied to setting patterns as were seen in the Gulf of Mexico. Many sets were also observed over deeper water depths: 6% in less than 200 meters, 17% between 200 meters and 499 meters, 32% between 500 and 999 meters, 30% between 1,000 and 1,999 meters, and 15% over depths of 2,000 meters, or more.

Swordfish catch rates were slightly higher between 500 and 999 meters depth (8.9 per 1,000 hooks) as compared to shallower depths, whereas catch rates for bigeye tuna were 50% higher beyond 1,000 meters depth. Yellowfin catch rates were the highest between 500 and 999 meters, but declined only slightly beyond 1,000 meters (from approximately seven to six per day). Swordfish catch rates beyond 1,000 meters declined by about half compared to the 500 to 999 meter depth strata. Although the sample was limited, coastal shark catch rates were the highest in depths less than 200 meters, and appear to decline as depth increases from between 200 and 499 meters to depths beyond 2,000 meters.

Catenary rigs were as variable as in the SAB, but with a smaller percentage of the shallowest rigs: 9% less than four hooks, 32% with four hooks, 34% with five hooks, and 24% with six hooks, or more. Blue marlin and bluefin tuna had higher CPUEs in depths beyond 1,000 meters when the catenaries were rigged shallow with four hooks or fewer between floats. White marlin had higher CPUEs with the shallowest catenaries (less than four hooks), although samples were limited in shallow depths. For yellowfin tuna, the catenary with five hooks between floats had the highest CPUEs between 200 and 999 meters. For swordfish, while shallow catenaries in depths less than 1,000 meters had the highest CPUEs (between 7.3 and 16.5), in deeper water, the difference between four-hook catenaries (4.3 swordfish per 1,000 hooks) and catenaries of six or more hooks (4.7 swordfish per 1,000 hooks) is probably insignificant.



MID-ATLANTIC BIGHT (MAB) CATCH DISPOSITION

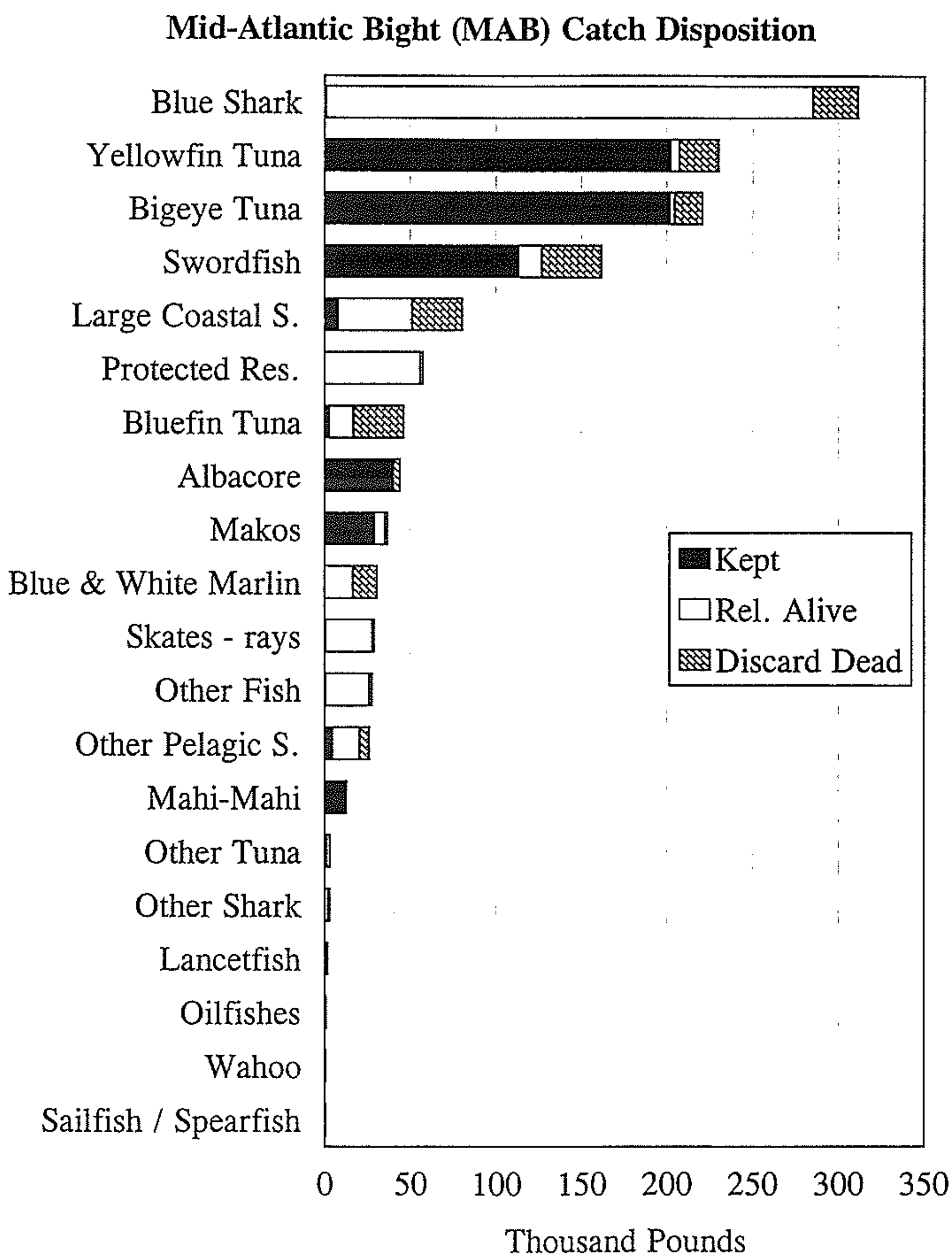
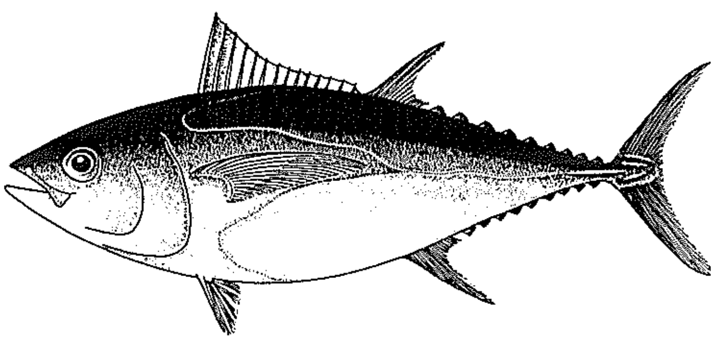


FIGURE 20. The catch disposition histogram in descending order of weight for sets in the MAB area.

NORTHEAST COASTAL (NEC)

The Northeast Coastal area had 338 observed sets, with 67% observed in the 3rd quarter, 22% in the 4th, and 11% in the later part of the second quarter. This pattern is consistent with seasonal temperatures and the availability of the target species in the area. Figure 21 presents the catch disposition histogram in descending order of weight for sets in the NEC area. As in the MAB, 85% of the sets fit the swordfish daily setting and hauling pattern, yet swordfish was the fourth ranked species by weight after blue sharks, yellowfin, and bigeye tuna. Depth distributions were very similar to the MAB, but with fewer sets in the shallowest depth and more sets over the deepest depths: 1.8% less than 200 meters, 20% between 200 meters and 499 meters, 21% between 500 and 999 meters, 25% between 1,000 and 1,999 meters, and 32% over depths of 2,000 meters, or greater. Nominal swordfish and yellowfin tuna catch rates were highest between 200 and 499 meters depth (7.2 and 13.4 per day, respectively). For swordfish, catch rates varied little between deeper depth strata, while catch rates for bigeye tuna in depths beyond 1,000 meters were triple those of shallower depths. The proportions of catenary rigs (hooks between floats) was similar to the MAB: 10% less than four hooks, 33% with four hooks, 30% with five hooks, and 27% with six hooks, or more. Catch rate patterns for depth and catenary combinations were similar to those described for the MAB.



NORTHEAST COASTAL (NEC) CATCH DISPOSITION

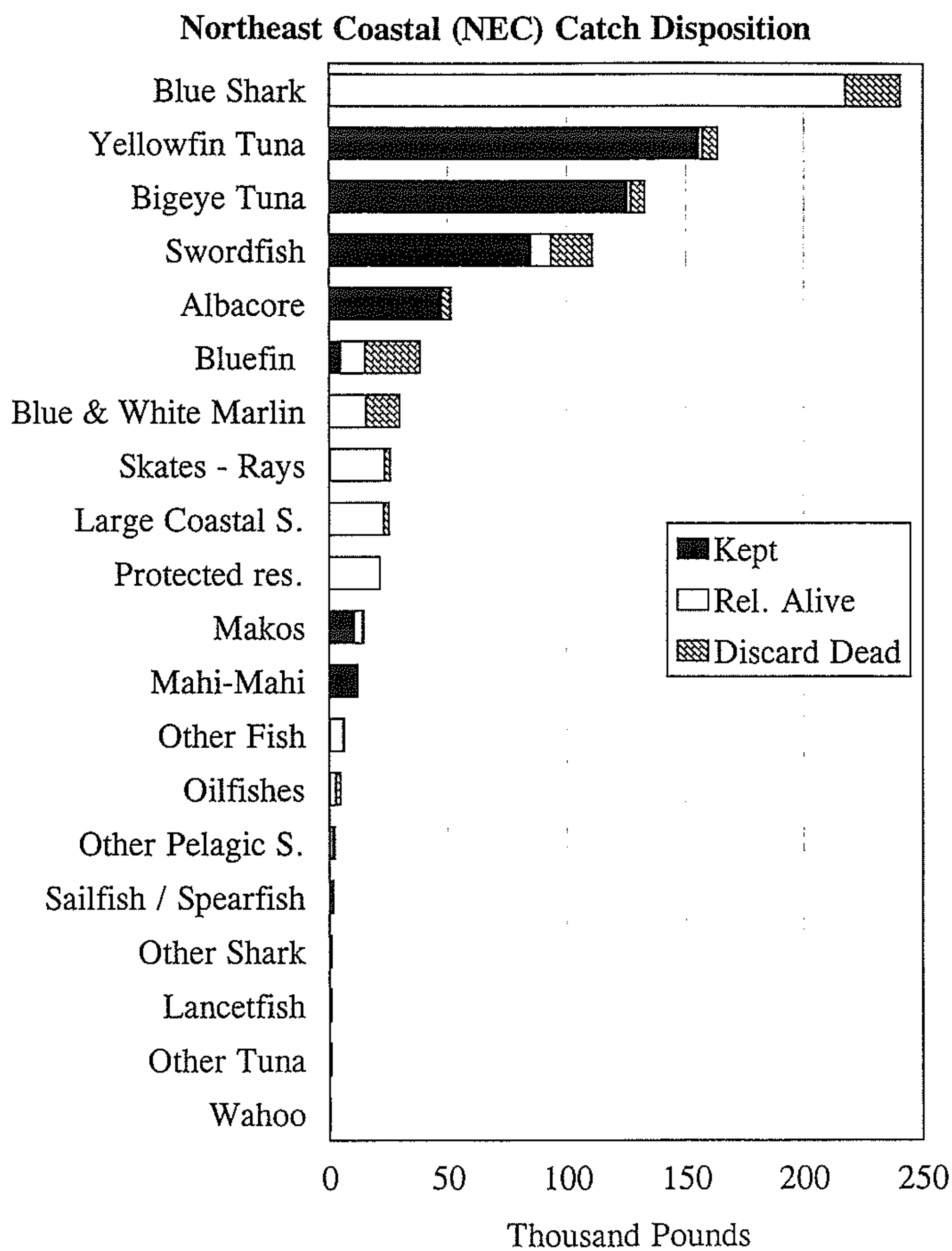
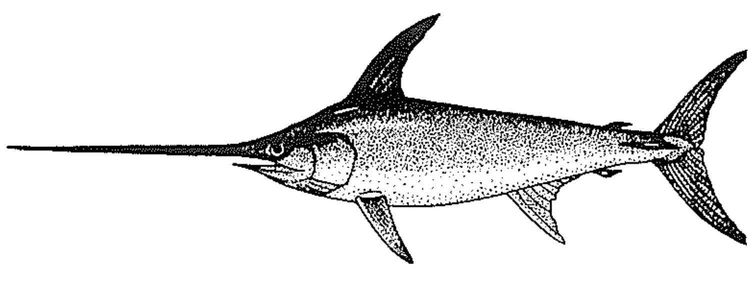


FIGURE 21. Catch disposition histogram in descending order of weight for sets in the NEC area

NORTHEAST DISTANT (NED)

The Northeast Distant area had 338 observed sets, with 53% in the 3rd quarter, 44% in the 4th quarter, and 2% in the last month of the 2nd quarter. Figure 22 presents the catch disposition histogram in descending order of weight for sets in the NED area. In terms of targeting, 91% of the sets fit the swordfish daily setting and hauling pattern. In contrast to the MAB and NEC areas, swordfish was ranked number one followed closely by blue sharks, then bigeye tuna and mako with significantly lower total poundage. There was little diversity in terms of depth distribution with all observed sets recorded beyond 1,000 meters, and 93% in 2,000 meters or more. There was also very little variability in catenary rigs (hooks between floats) except that a greater number of sets were rigged very shallow: 3.6% with two hooks, 76.6% with three hooks, 12.1% with four hooks, and 7.7% with five hooks. In terms of swordfish catch rates, the three-hook rigs had a mean of 31 swordfish per 1,000 hooks, whereas the four-hook-and-five-hook rigs had catch rates of 27 and 26 per 1,000 hooks, respectively. In terms of swordfish discards, the five-hook rig averaged 12 per 1,000 hooks compared to 9.5 and 8.5 for the four-and-three-hook rigs, respectively. Given the shallow thermocline that characterizes this region, the sets with five- hook catenary rigs were probably in warmer water temperatures associated with the Gulf Stream or deeper portions of oceanographic eddies. Fishing strategies in this region are particularly focused on dynamic frontal systems, where attempts are often made to fish in the colder edges of these fronts where the temperature change is the greatest, the thermocline is the shallowest (hence shallow catenaries), and the swordfish are generally larger.

In contrast to the MAB and NEC areas where about 90% of the blue sharks were released alive (in both number and weight), in this area only 68% were released alive in number and 77% by weight. While examining frequency distributions of the total numbers of pelagic sharks discarded by trip and mean pelagic shark catches per day, four trips were identified that had mean daily pelagic shark catches that ranged from 56 to 82. These were the highest average daily catch rates observed for pelagic sharks and these same trips also accounted for some of the largest absolute numbers of blue sharks that were discarded dead. These four trips accounted for 78 sets or 2.3% of the observed pelagic effort, yet they accounted for 24% of the total observed pelagic shark catch and 40% of all the pelagic sharks that were reported by observers as dead discards. Based on observer notes and subsequent discussions with the captains, the dead discards resulted from efforts to retrieve hooks so that the gear costs for the trip would not be excessive and to ensure that the hook supply on board would last for the entire trip.



NORTHEAST DISTANT (NED) CATCH DISPOSITION

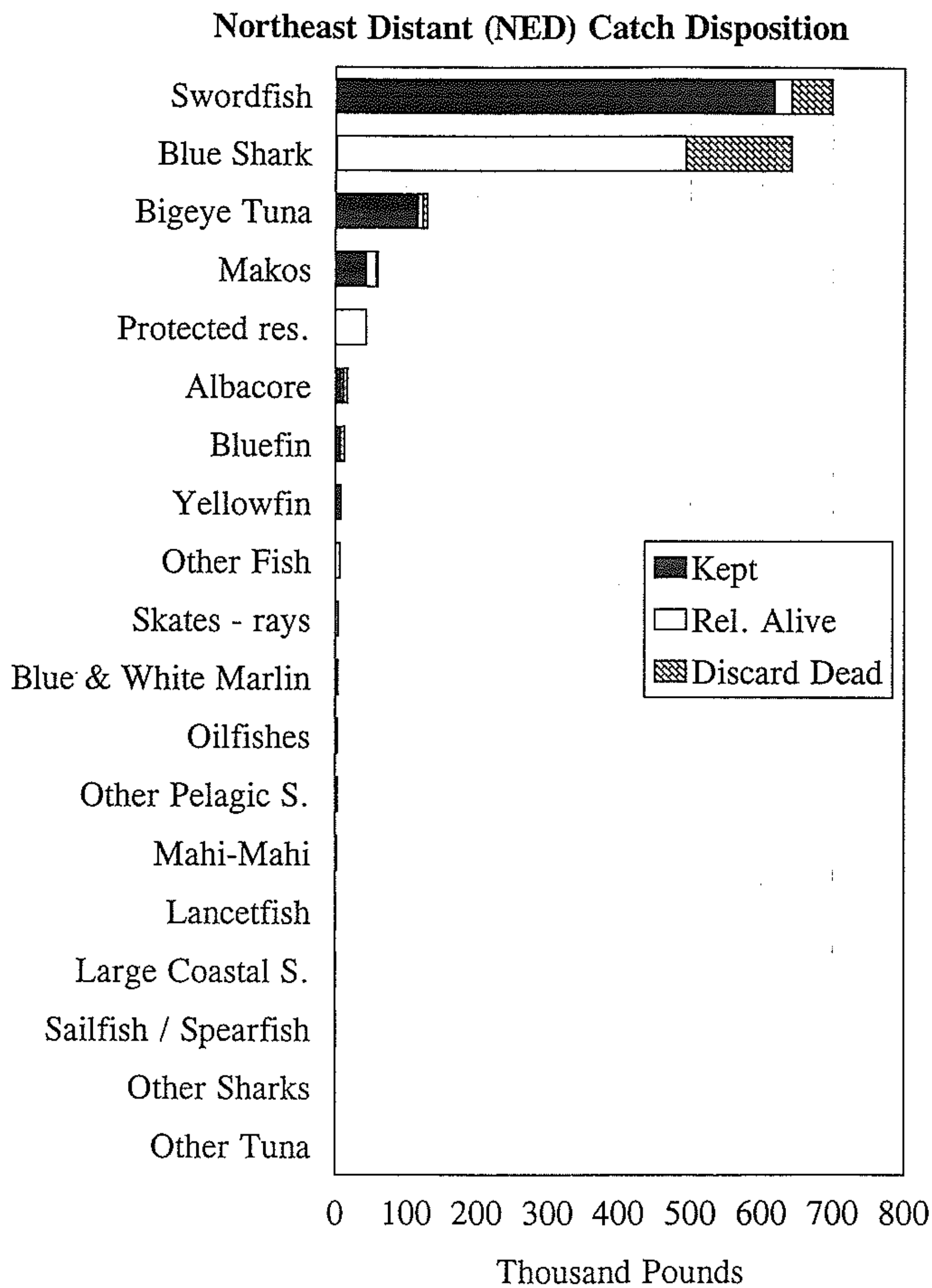


FIGURE 22. Catch disposition histogram in descending order of weight for sets in the NED area

SPECIES DISTRIBUTIONS/NOMINAL CATCH RATES

Preceding sections of this report have demonstrated that interactions (numbers observed) and interaction rates (abundance) vary for a variety of target and bycatch species by time, area, and gear configuration. It has also been demonstrated that many of the incidentally captured species are rare components of the total catch with very low average daily catch rates (Figures 12 and 13). High interaction rates for some species are clustered events where a very limited number of sets account for a disproportionate catch of that species or species group. This was illustrated for dead discards of blue sharks in the NED area and for targeted shark effort that was identified as distinct sets based on gear and operating practices. In these cases, small proportions of sets accounted for very significant proportions of the total pelagic and coastal shark catch and discards. Identifying the environmental and operating conditions that appear to contribute to high interaction rates provides an opportunity to identify practices (when, where and how the gear is set) that could reduce bycatch interactions or increase the survival of incidentally captured animals that could not be avoided.

The following section provides species distribution and nominal catch rate maps for ten species. Short case studies follow with additional maps for another six species. Two basic map views are provided. One covers all of the areas sampled. Another shows in reduced scale the GOM, FEC, SAB, MAB, and NEC areas. Reference maps illustrating the distribution of observed pelagic longline sets within these views are also provided. Nominal catch rates are in number caught per day, which varies by species. For the larger scale view, catch-per-day values are as follows for the following species:

- Yellowfin tuna - catch/day from one to five, and six or more (Figure 23)
- Bigeye tuna - catch/day from one to five, and six or more (Figure 24)
- Blue shark - catch/day from one to five, and six or more (Figure 25)
- Mako shark - catch/day from one to three, and four or more (Figure 26)
- Thresher shark - catch/day from one to two, and three or more (Figure 27)
- Observed effort all areas (Figure 28).

For the reduced scale view (GOM, FEC, SAB, MAB, and NEC), catch per day values are as follows for the following species:

- Silky sharks - catch/day one, two to four, and five or more (Figure 29)
- Sandbar sharks - catch/day one, two to four, and five or more (Figure 30)
- Hammerhead sharks - catch/day one, two to four, and five or more (Figure 31)
- Dusky sharks - catch/day one, two to four, and five or more (Figure 32)
- Tiger sharks - catch/day one, two to four, and five or more (Figure 33)
- Observed effort GOM, FEC, SAB, MAB, NEC (Figure 34)

The large scale maps for yellowfin, bigeye, blue shark, mako shark, and thresher sharks demonstrate the wide geographical range of these species. High nominal catch rates and most positive catch rates occur beyond the 1,000-meter depth contour for the tunas and blue sharks. Thresher and mako sharks are frequently caught along the 1,000 meter contour or in water most likely associated with the offshore Gulf Stream, especially north of 35^0 N. South of 35^0 N, these species show a greater tendency to occur inside the 1,000-meter contour in the FEC and SAB areas, while GOM distributions are more widespread. The smaller scale maps demonstrate a range of distribution patterns for five additional sharks (silky, sandbar, hammerhead, dusky and tiger shark). This smaller map scale was chosen because a greater overall proportion of the total catch of these species was found within the GOM, FEC, SAB, MAB, and NEC areas.

In an earlier section, shark-targeted longline sets were identified because they were characterized by unique locations (more shallow depths) and gear configurations (bottom gear and large numbers of hooks between floats). On the remaining 3,334 pelagic longline sets, silky sharks (1,905), dusky (1,122), hammerheads (725), tiger (351), and sandbars (333) account for 82% of the coastal shark catch. Distribution maps are presented for these dominant species. If a small number of sets account for a disproportionate catch of these species, avoiding those conditions could result in significant reductions in shark bycatch. Recognizing the catch of three or more of any of these species on a single set as a sign of high bycatch is a useful operating guideline.

For silky sharks, 92 out of 593 positive sets caught more than 4 silky sharks, accounting for 49% of the total silky catch. About 40% of these sets occurred in the GOM and 67% occurred in depths less than 1,000 meters. South of 35^{0}N the distribution of silky catches is very similar to the overall distribution of observed effort, while in the GOM high silky catches (>four) appear to be associated with swordfish effort (depths < 1,000 meters and morning gear retrievals) rather than tuna effort. This indicates that efforts to reduce swordfish discards, especially in the GOM, FEC, and SAB areas where depths shallower than 500 meters should be avoided, may also reduce silky discards.

Sandbar sharks (n = 333) were observed on only 147 sets. Nine sets caught more than four sandbar sharks, accounting for 31% of the total sandbar catch. Six of these sets were in depths shallower than 500 meters. Sandbar sharks are obviously distributed on the shallow side of the overall effort distribution. The hammerhead distributions showed a similar tendency especially in the SAB area along the 500-meter depth contour, although for both of these species higher percentages were caught in the MAB area. Both species distributions seem to be tied more to the edge of the continental shelf in contrast to the distributions for the dusky and tiger sharks.

Dusky sharks were caught on 400 sets, with 55 sets (catch-per-day greater than four) accounting for 52% of the total dusky catch. March and April sets in the SAB area accounted for 23 of these sets and 35 were in depths shallower than 500 meters. Offshore capture locations are most likely associated with warmer Gulf Stream water. Tiger sharks demonstrate a very similar distribution pattern, particularly north of 35^{0} N.

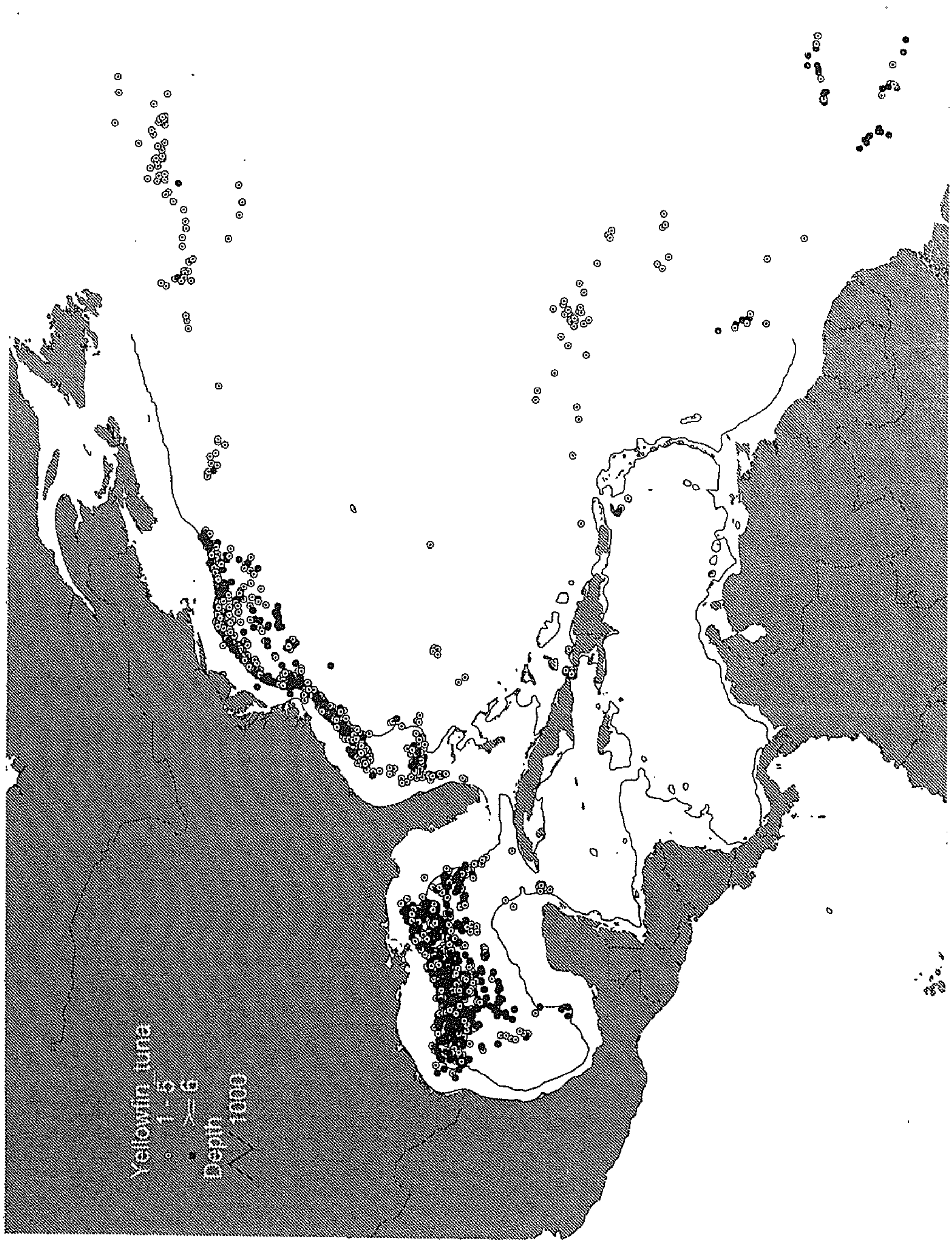


FIGURE 23. Yellowfin tuna distribution and nominal catch rates.

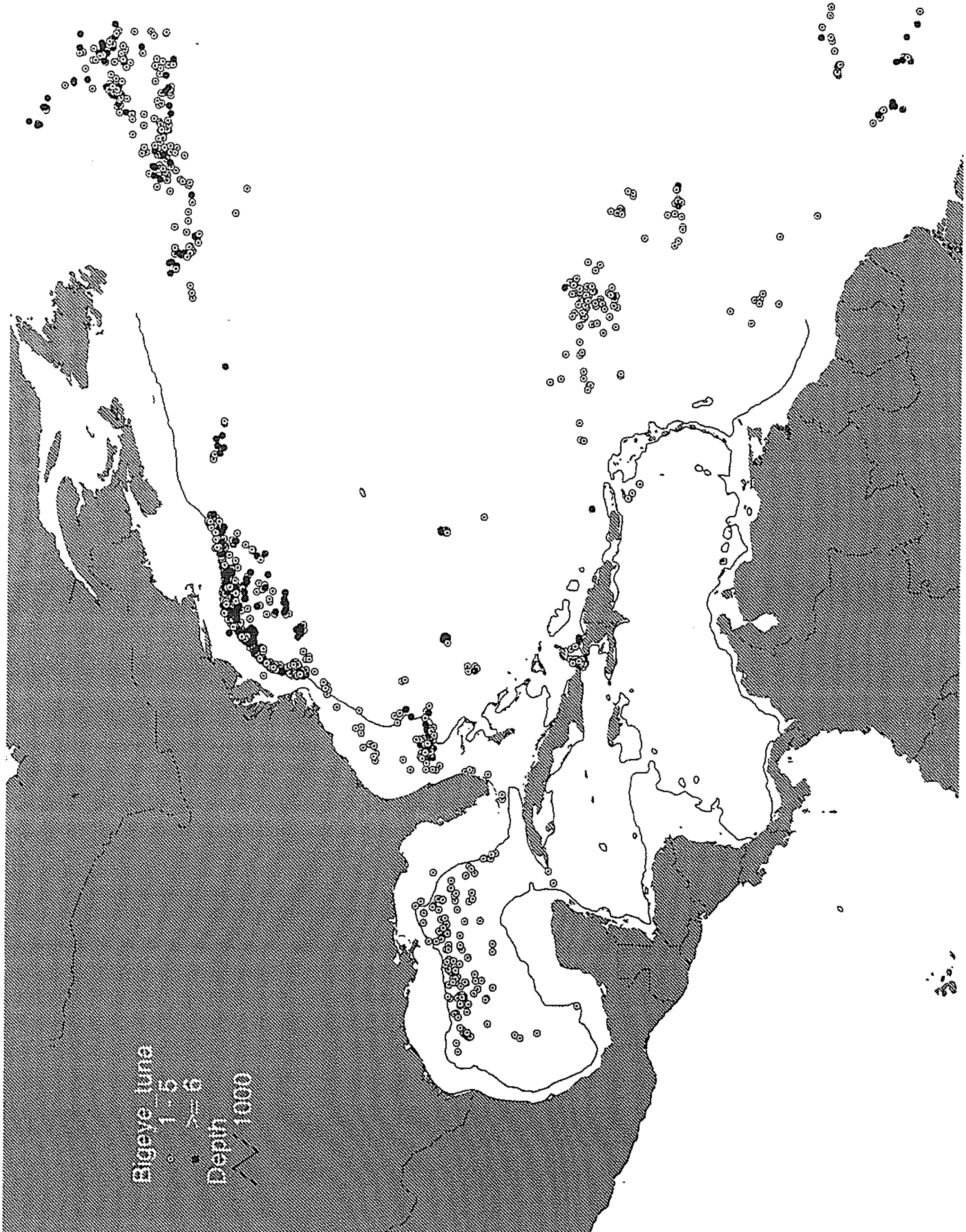


FIGURE 24. Bigeye tuna distribution and nominal catch rates.

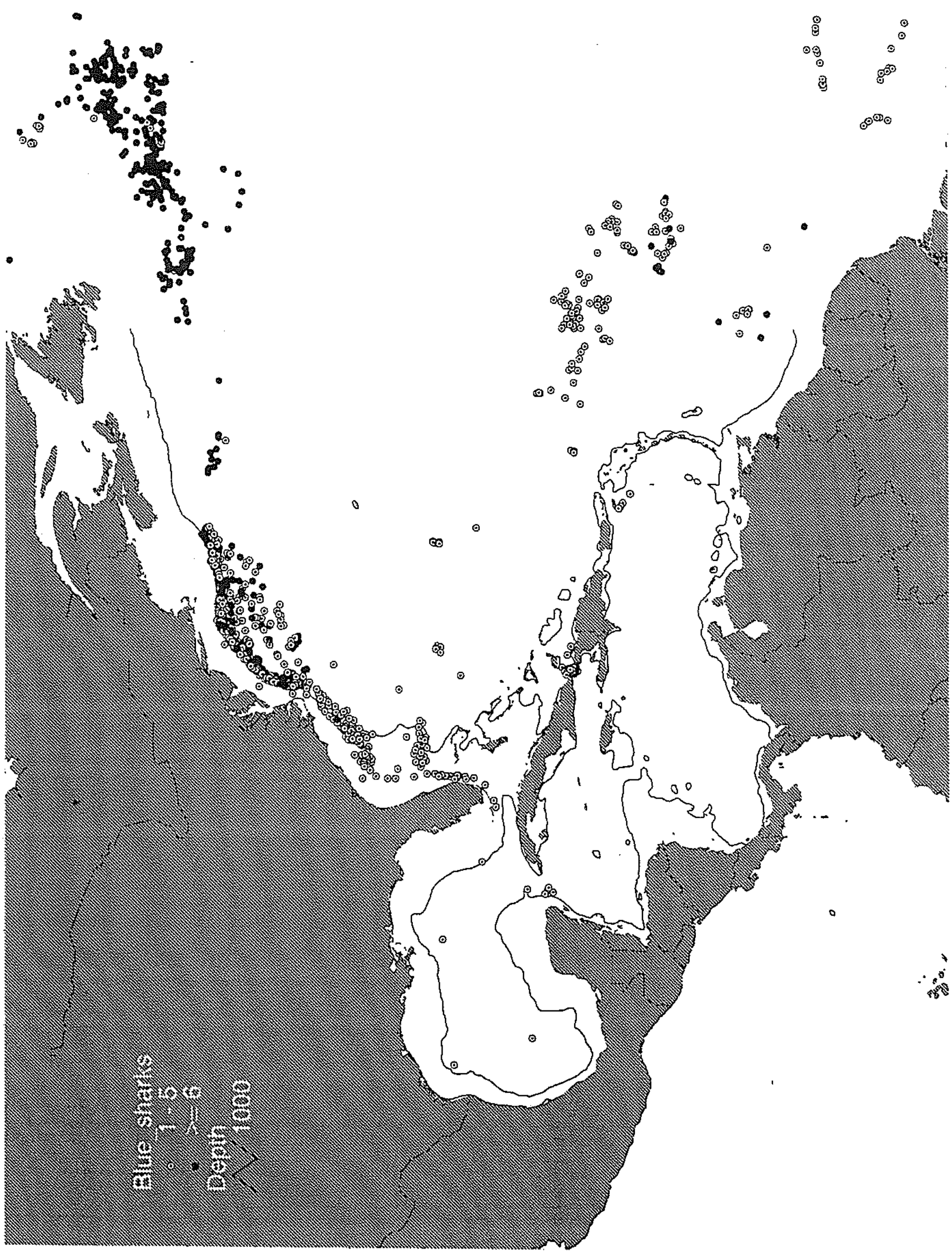


FIGURE 25. Blue shark distribution and nominal catch rates.

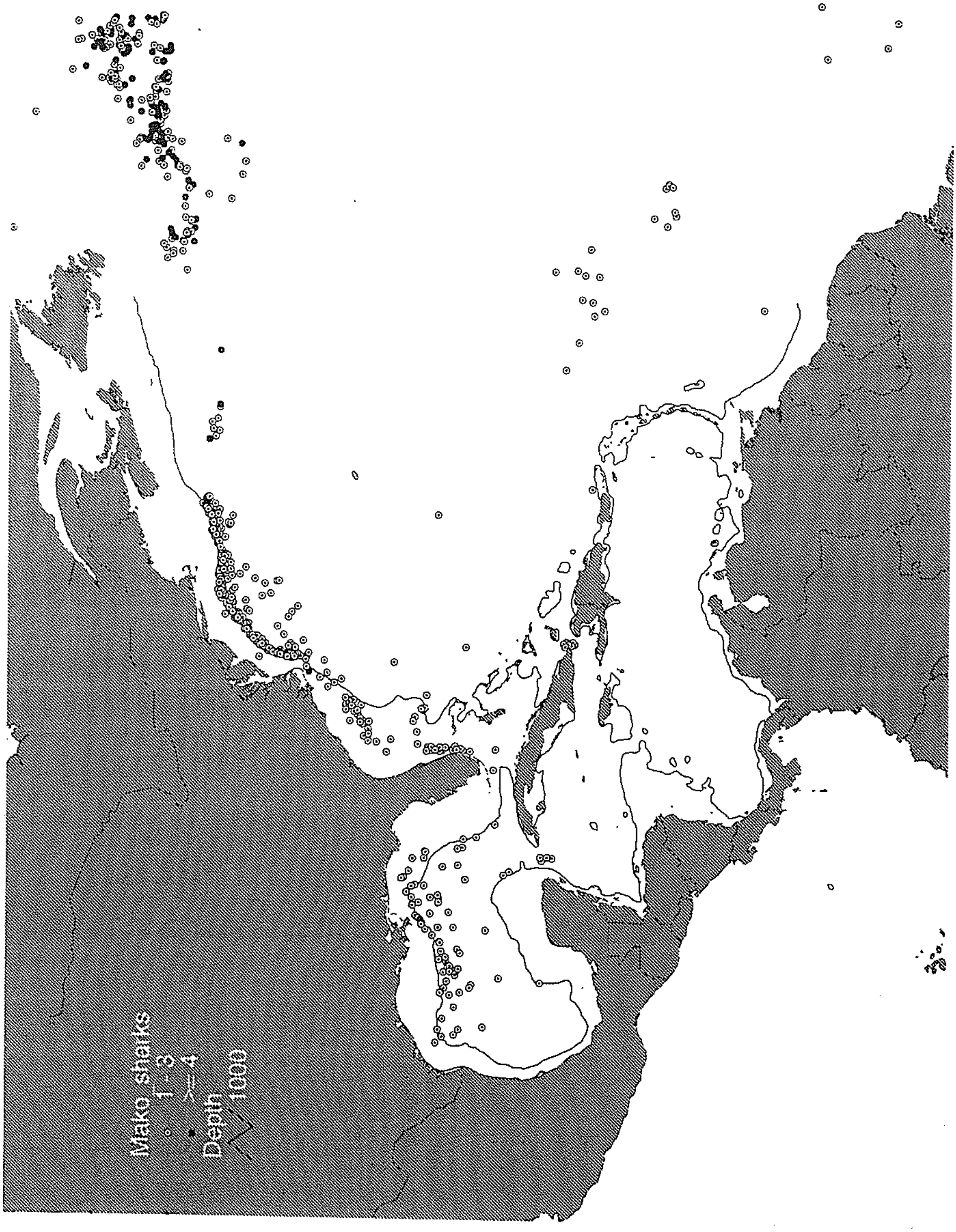


FIGURE 26. Mako shark distribution and nominal catch rates.

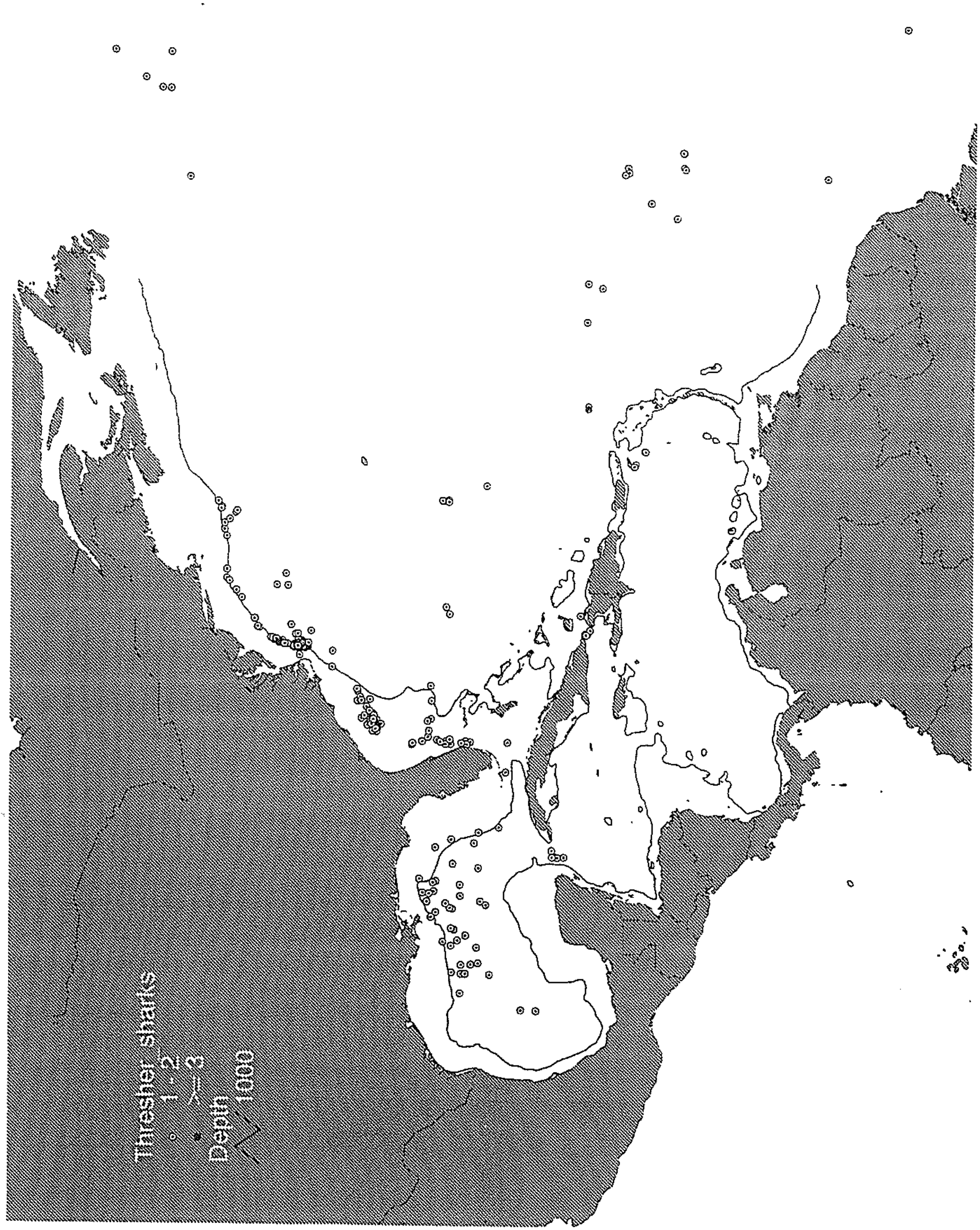


FIGURE 27. Thresher shark and tuna distribution and nominal catch rates.

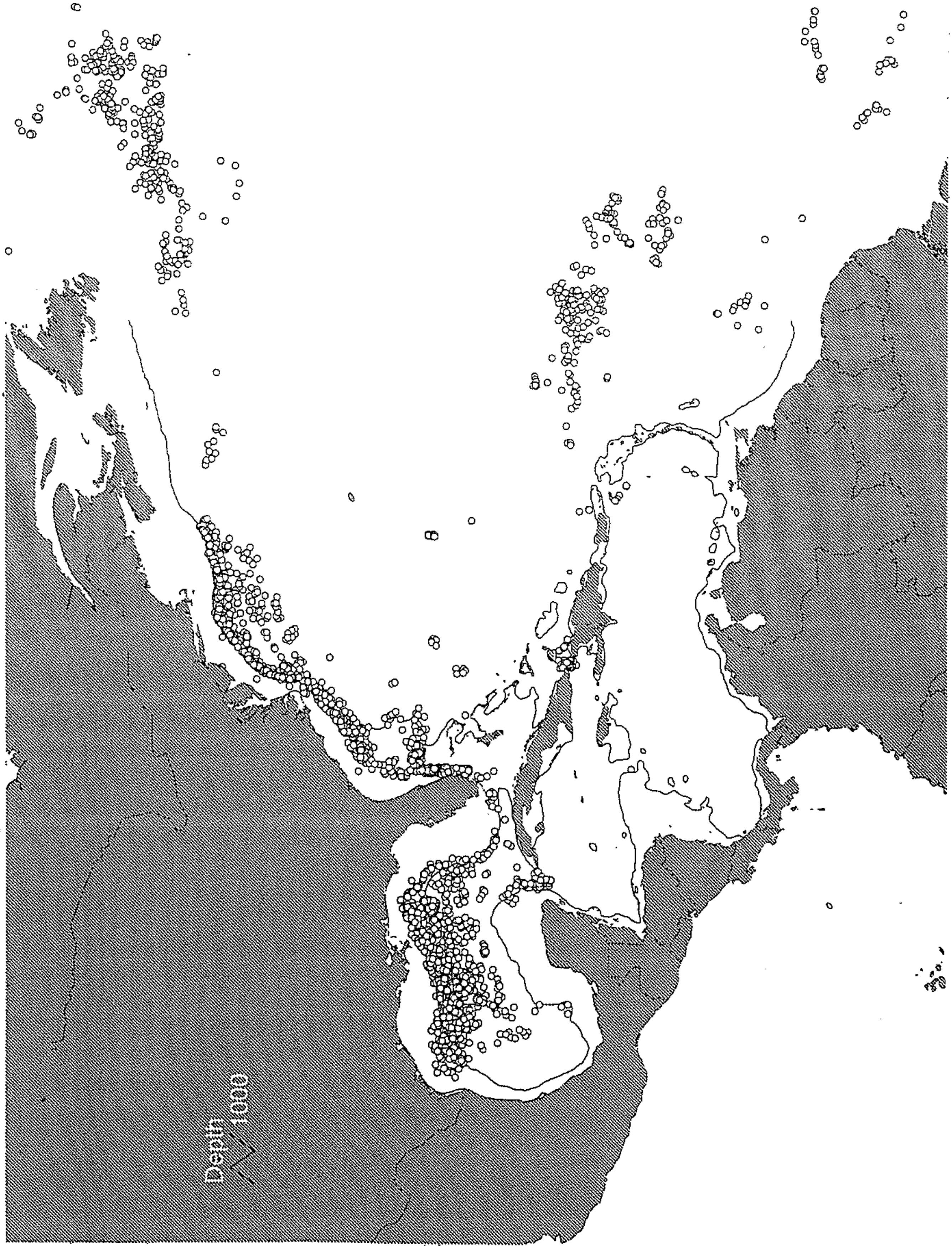


FIGURE 28. The distribution of observed sets for all areas.

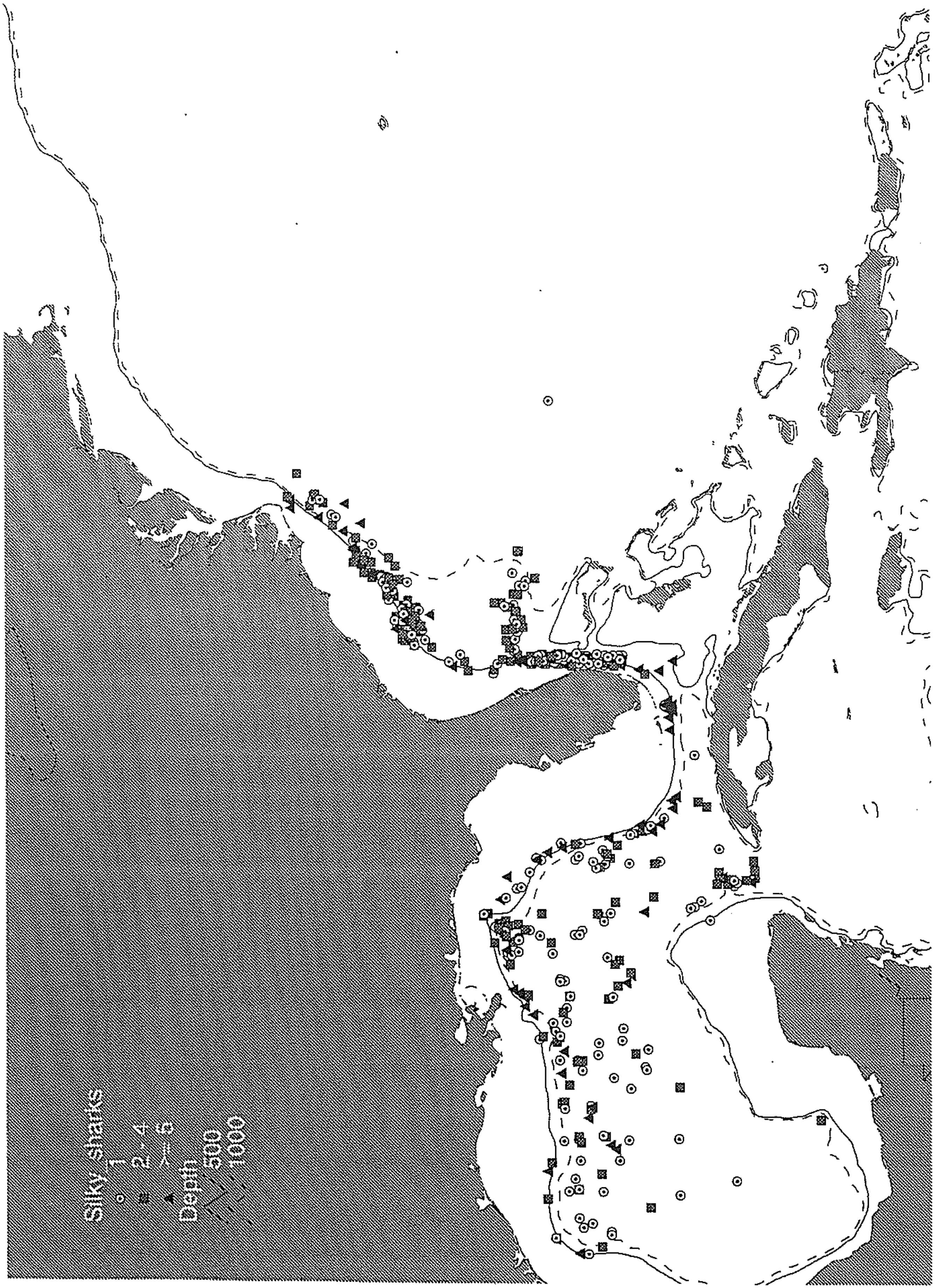


FIGURE 29. Silky shark distribution and nominal catch rates.

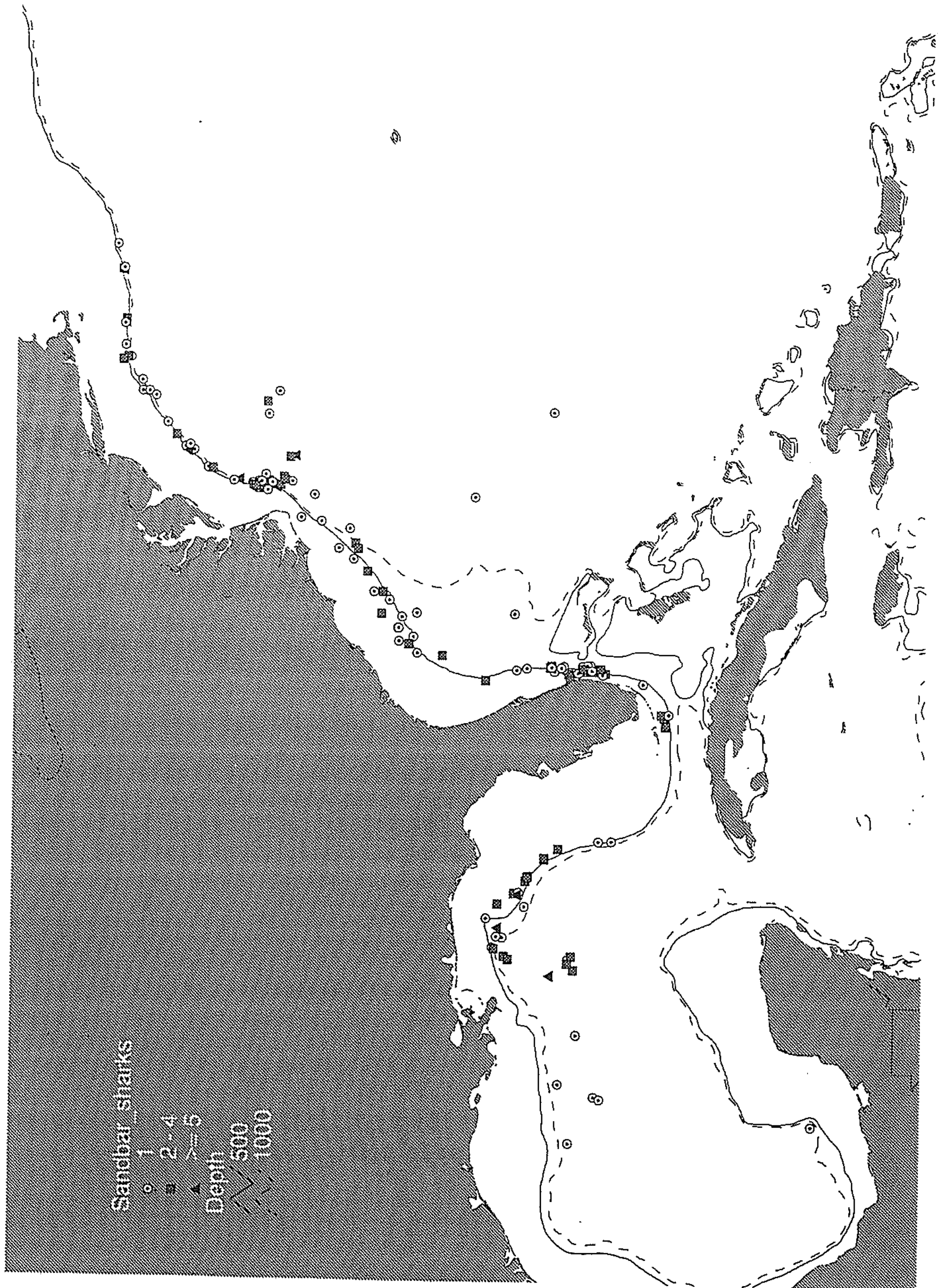


FIGURE 30. Sandbar shark distribution and nominal catch rates.

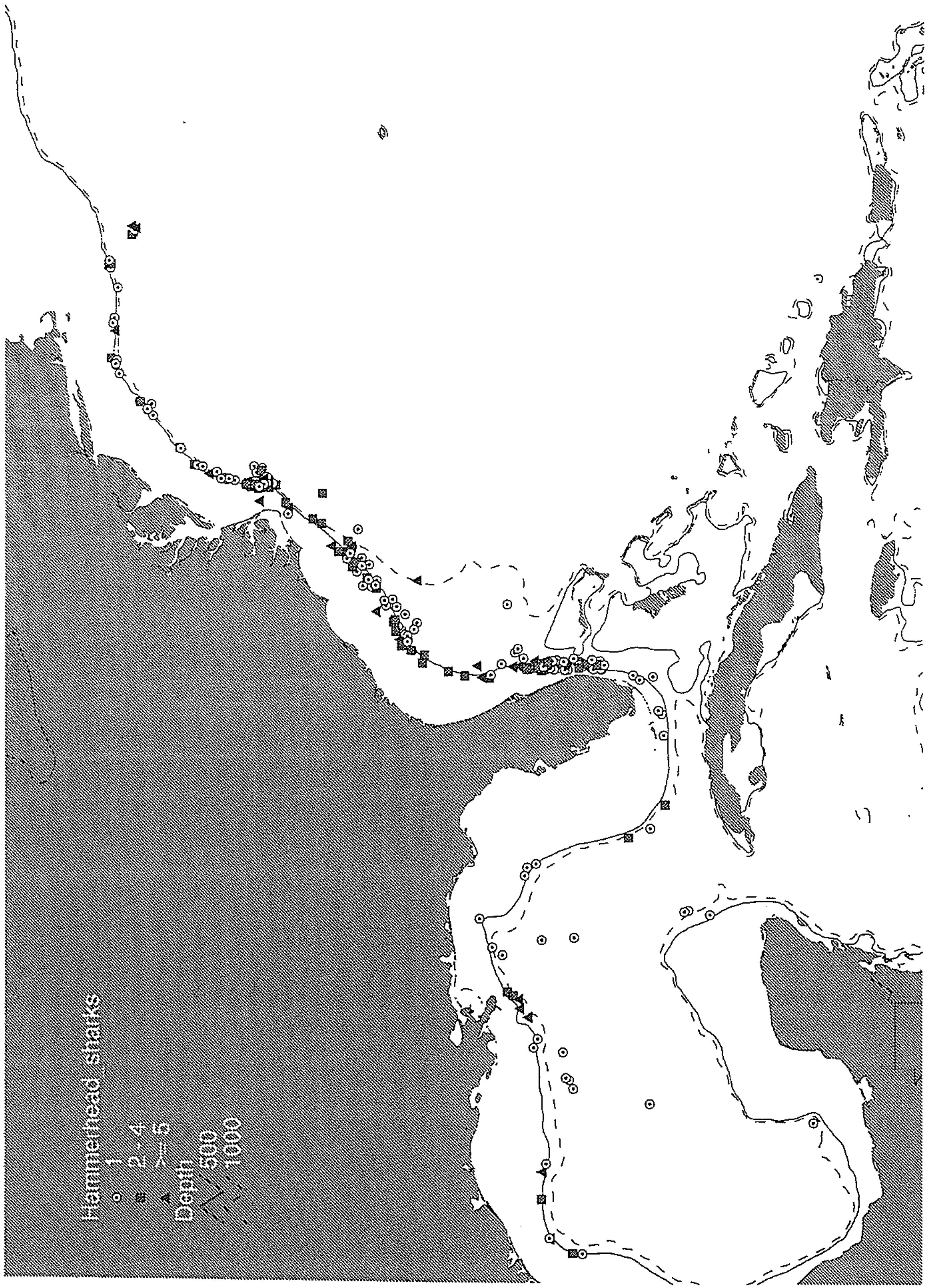


FIGURE 31. Hammerhead shark distribution and nominal catch rates.

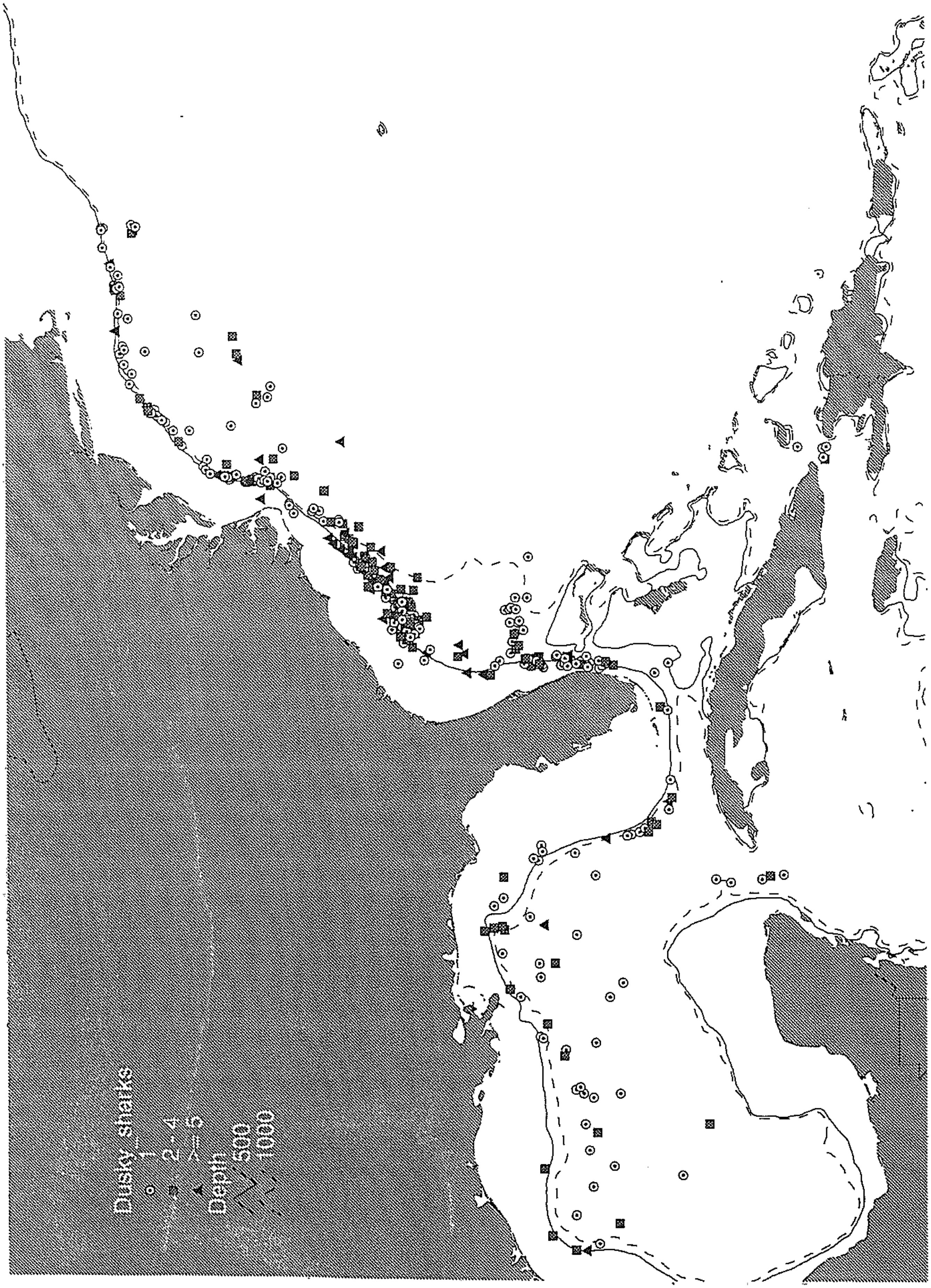


FIGURE 32. Dusky shark distribution and nominal catch rates.

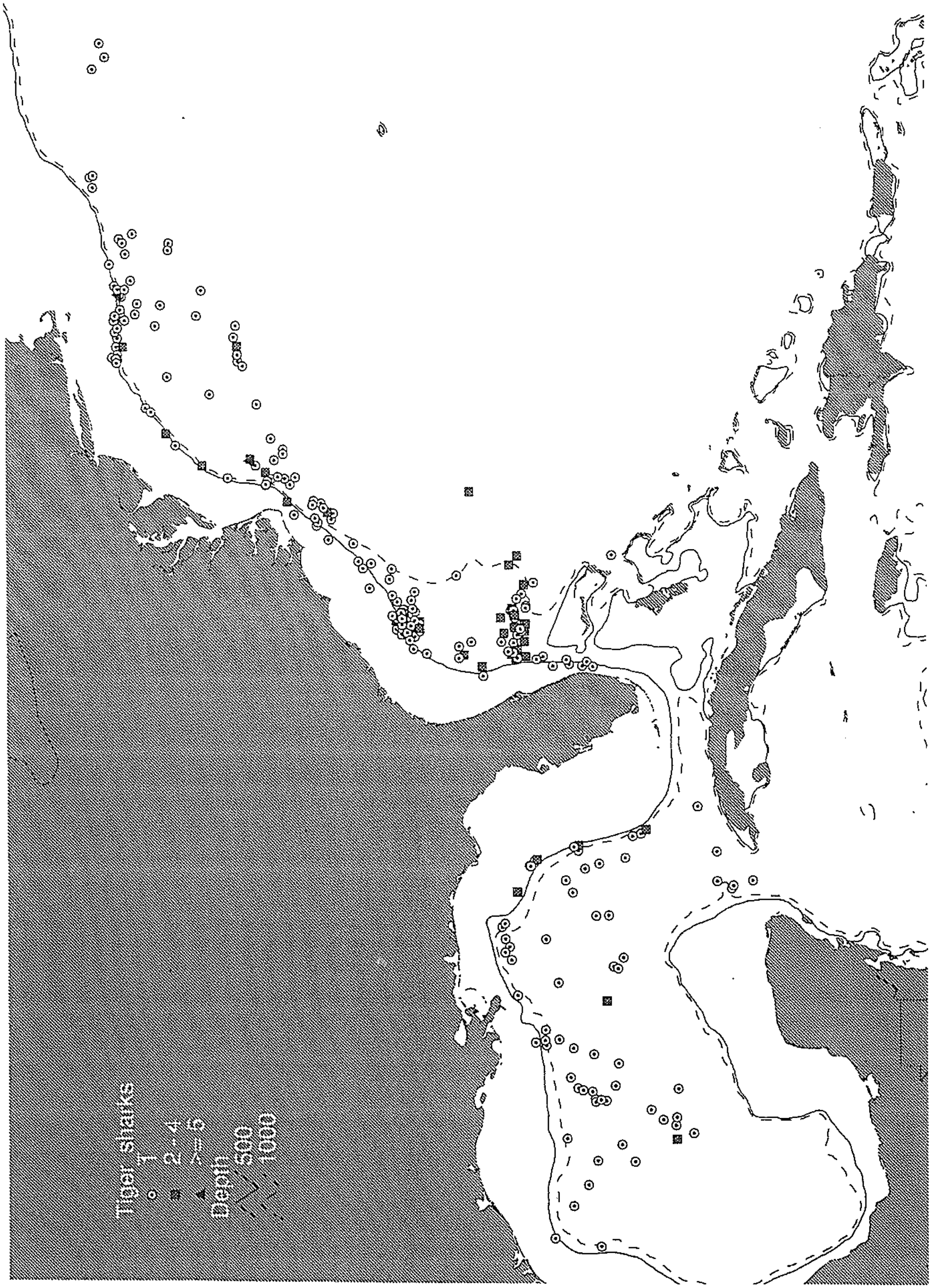


FIGURE 33. Tiger shark distribution and nominal catch rates.

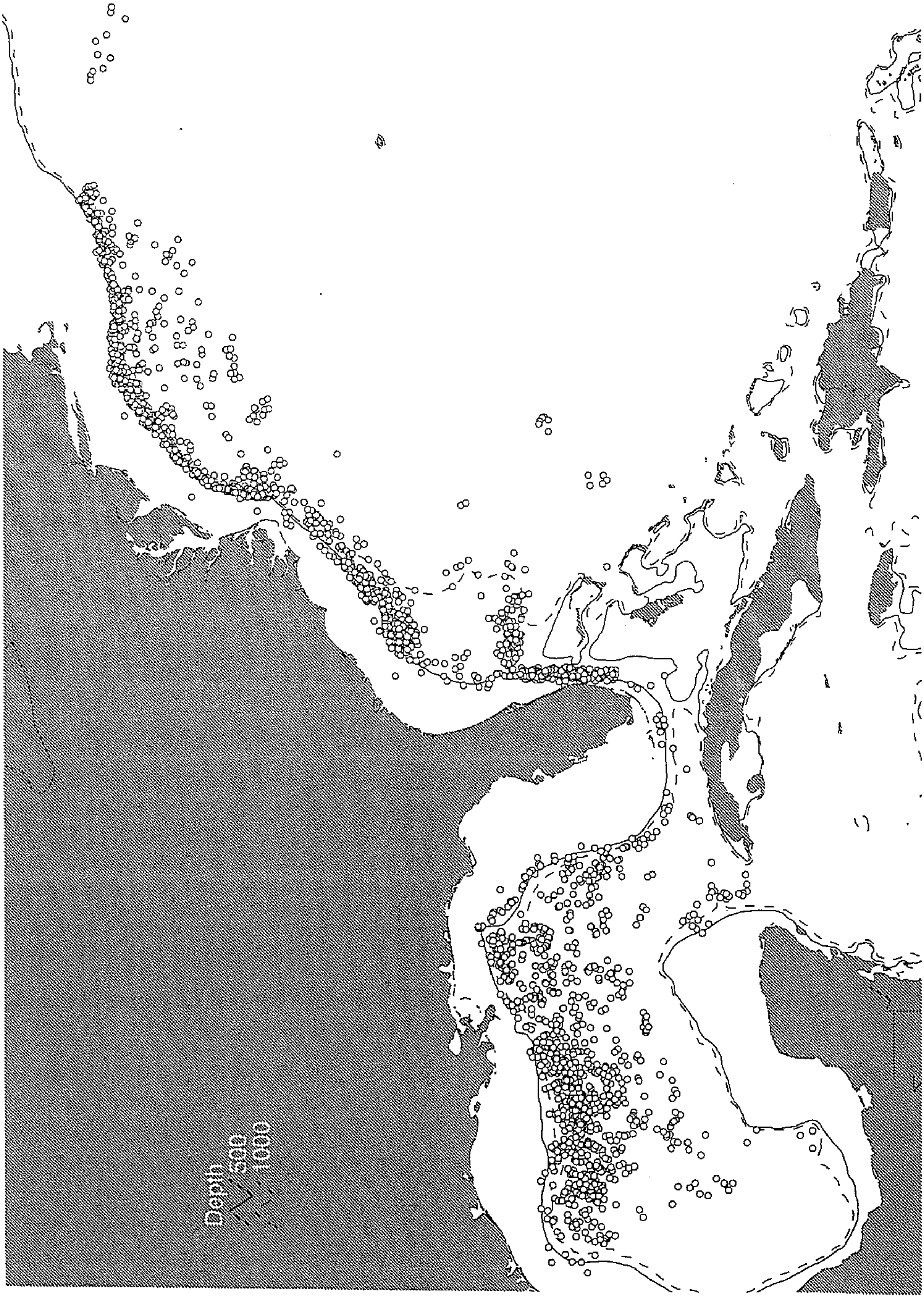


FIGURE 34. The distribution of observed sets in the GOM, FEC, SAB, MAB, and NEC areas.

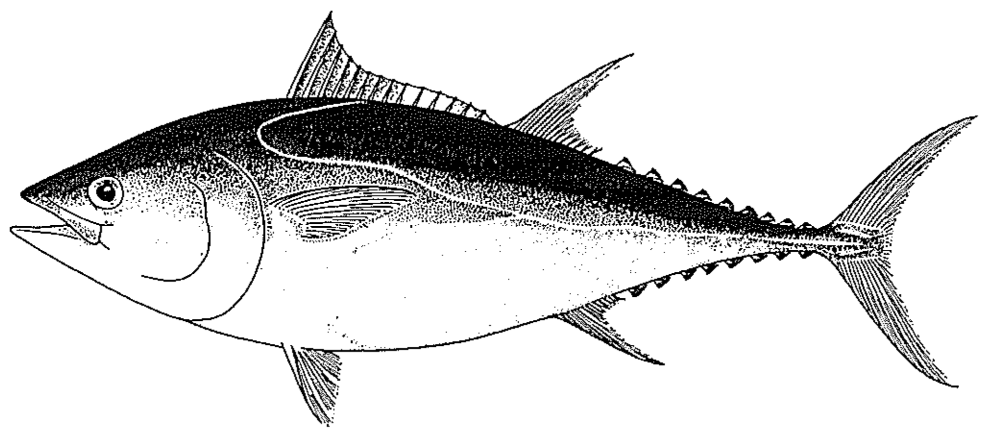
CASE STUDIES

FOR

BLUEFIN TUNA
SEA TURTLES
SAILFISH AND MARLIN
SWORDFISH

CASE STUDY – BLUEFIN TUNA

Of the 776 bluefin reported by observers, 11 were associated with the 63 sets that targeted sharks. The remaining 765 bluefin were attributed to pelagic longline sets that occurred in seven of the nine areas covered, although the vast majority were observed in the MAB and NEC areas. For the pelagic longline sets, two trips accounted for 0.75% of the observed sets (25 out of 3,334 sets) and 55% of the bluefin catch (420 out of 765). Both trips occurred during June along the edge of the continental shelf off southern New England. The dates, locations, and sea surface temperatures associated with these 25 sets were compared to sea surface temperature charts developed from satellite imagery. The trips were associated with entrained slope water and Gulf Stream eddies that occupied slightly different areas along the edge of the shelf in different years. A similar pattern has been observed in the mandatory logbook records of daily catch and effort. Figure 35 illustrates the locations of positive bluefin sets off the east coast and in particular observed sets that caught five or more bluefin on a single set. Because this pattern was consistent in both logbook and observer data, a closed area was established during the month of June to reduce the likelihood of these high bluefin catch rates. The effectiveness of this area closure will depend on the degree to which the oceanographic eddies are consistently found during June within that closed area.



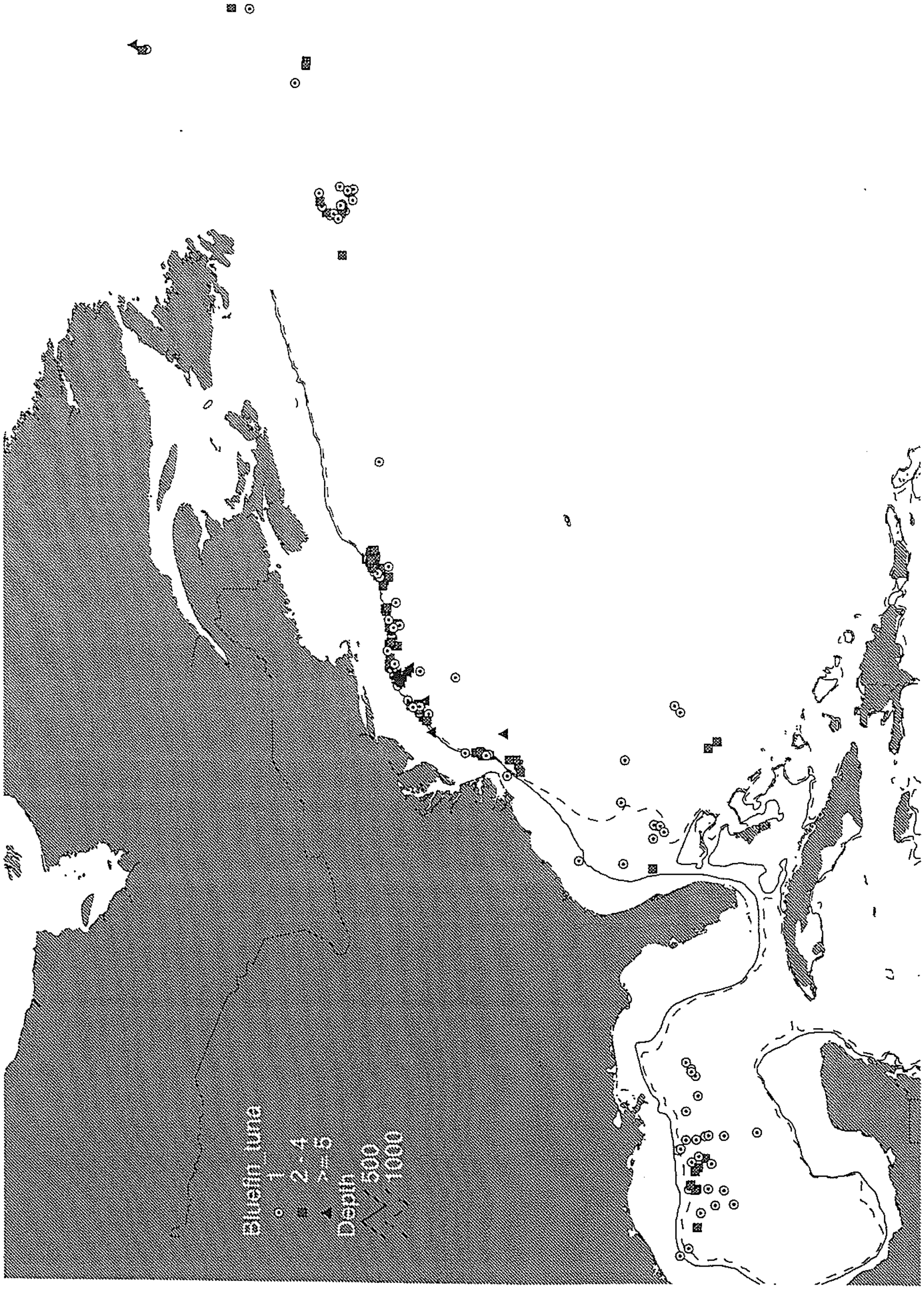


FIGURE 35. Positive catch locations for bluefin tuna.

CASE STUDY - SEA TURTLES

Observers recorded 528 sea turtles caught on 3,334 pelagic longline sets and one turtle caught on shark targeted effort. Of the 528 turtles, 522 were released alive (98.8%), five were discarded dead and one was coded as condition unknown. Loggerhead, *Caretta caretta* (283) and leatherback, *Dermochelys coriacea* (214) turtles were clearly predominant. Observer notes indicated that some turtles might have been caught more than once (on subsequent days), because clean hooks were observed in the jaws of some turtles during trips that caught large numbers of turtles over 14 to 20 day periods. While turtles were observed in all areas, 56% were recorded in the 3rd and 4th quarters in the NED area and 79% were observed north of 35^0 N latitude (Figure 36). The top four trips in number of sea turtles caught accounted for 2% of the observed effort but 38% of the total turtle catch. These trips and four others that caught 10 or more turtles were all in the NED area. These unusual trips were most likely associated with Gulf Stream eddys (warm core rings) near the Grand Banks based on water temperatures and oceanographic analyses of satellite imagery. Subsequent discussions with the captain of one of these vessels indicated that he had been fishing on a decaying warm-core ring that was surrounded by much colder water. Turtle interactions, as well as daily sightings of turtles basking at the surface, increased during the trip as the size of the ring diminished, linearly and in depth, and as water temperature within the eddy declined.

While sea turtle captures are rare in general, they appear to be clustered events so that once an interaction has occurred, a second seems more likely. This is particularly true for loggerheads where 65% are caught on sets with other loggerheads, whereas only 32% of leatherbacks are caught with other leatherbacks. Multiple captures are particularly prevalent in the NED area, the only area where four or more turtles were caught on a single set. There were also 19 sets with three turtles and 22 sets with two turtles in the NED area. In the MAB and NEC areas, there were three sets that caught three turtles and 11 sets that caught two turtles. There were only nine additional sets observed with two turtles in all remaining areas. Based on these analyses, captains would be well advised to adjust the area or style of fishing once they encounter their first turtle on a trip.

With respect to the NED area, analyses of operating, gear, and environmental conditions (sea surface temperatures) indicate that during the 3rd and 4th quarter, the following steps could reduce the probability of sea turtle captures:

- Avoid water temperatures greater than 68^{0}F when possible
- Delay setting until after 9 p.m.
- Set four or more hooks between floats and try longer gangions and droppers
- Consider switching to circle hooks to reduce foul and gut hooking of turtles

While these recommendations are based on a reasonable number of observed trips, certain options for surface temperatures and gear lengths may not be available (possible) given the conditions that are encountered on a specific trip. These analyses suggest that attention to the conditions that exist along the frontal system and attempts to fish in the coldest water available with deeper gear rigs once turtles have been encountered provide the best opportunity to limit subsequent turtle catches.

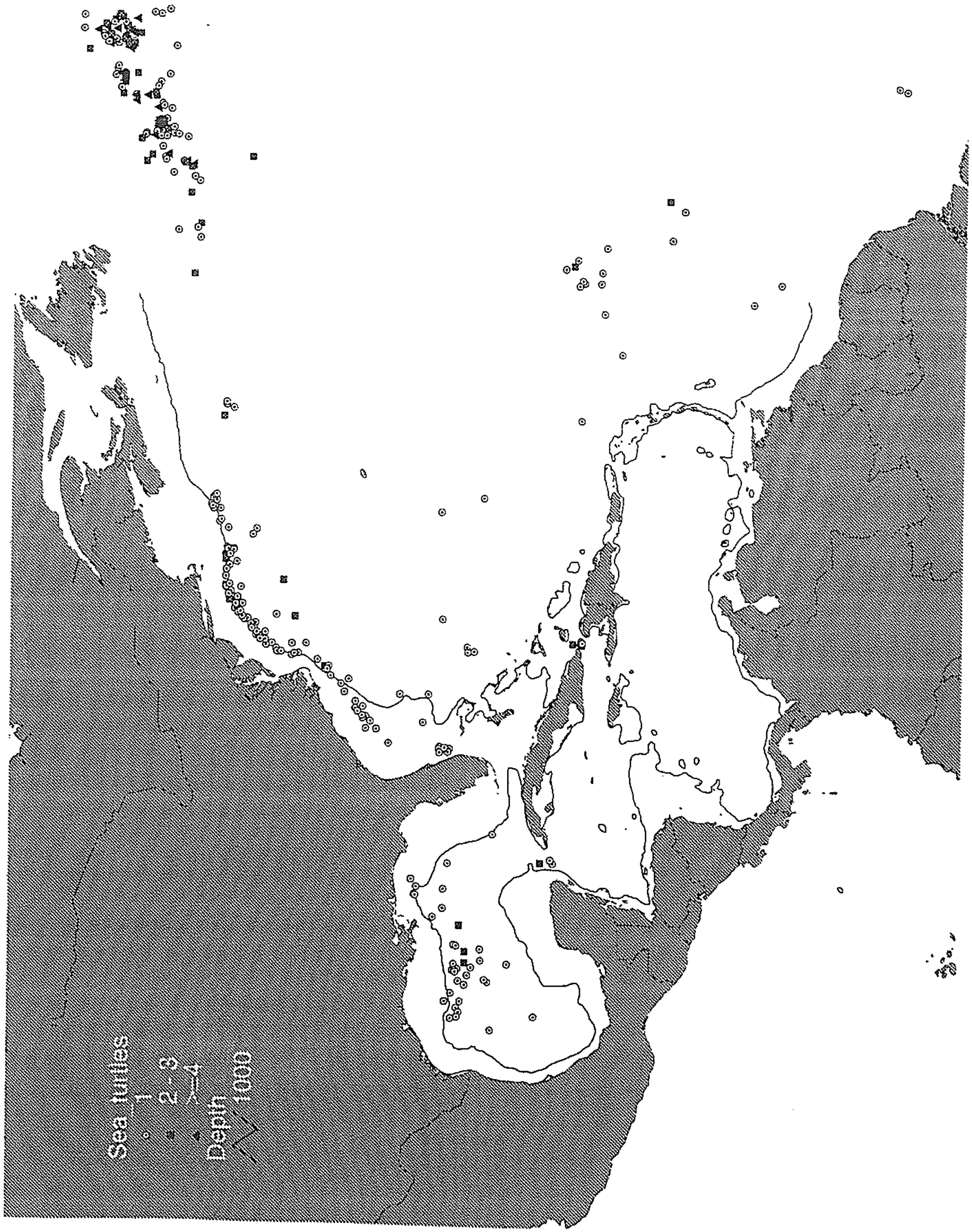
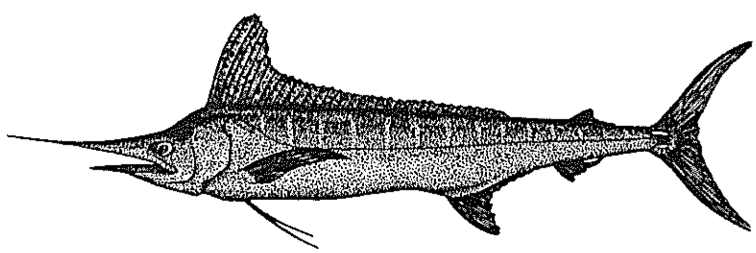


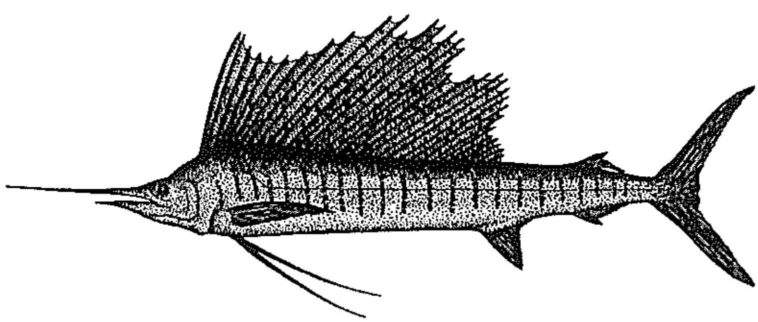
FIGURE 36. Positive catch locations for sea turtles.

CASE STUDY - SAILFISH AND MARLIN

Previous sections have described a number of factors that are associated with high sailfish, white marlin, and blue marlin catch rates. These included the finding that some of the highest observed catch rates for these species occurred in the TROP area. Sets in the GOM that targeted tuna, especially when the gear was tended and live bait was used, also produced high sailfish and marlin catch rates. Distribution maps are provided for blue marlin (Figure 37), sailfish (Figure 38), and white marlin (Figure 39). For sailfish and white marlin in particular, tuna targeting and live bait use are not indicated on the maps and this complicates the interpretation of the locations of high catch sets with respect to depth contours. For sailfish, the vast majority of high catch rate sets were associated with water temperatures greater than 81^0 F. For white marlin caught in the GOM area and north of 35^0 N, the comparable critical temperature for high catch rates appears to be between 76^0 F and 78^0 F.

While sailfish and marlin bycatch is a priority concern for sportfishermen, longline bycatch should be placed in perspective. The proportion of sets with zero catch rates for these species was 76% for white marlin, 82% for blue marlin, and 88% for sailfish. Half of the area/quarter strata (28) that have been observed have mean sailfish/marlin catch rates that are less than one per set. Of the sailfish/marlin that are caught, 47% are released alive. In comparison, for many of these strata between 10 and 20 marketable species are retained for every sailfish/marlin caught and about twice this number for each sailfish and marlin that is killed. Adjustments to the gear and operating practices associated with live bait use in the GOM can significantly reduce sailfish and marlin bycatch. Efforts to reduce effort in shallow depths while focussing effort in colder strata associated with frontal systems, or when these berths are taken by fishing deeper, should all contribute to reductions in sailfish and marlin catch rates.





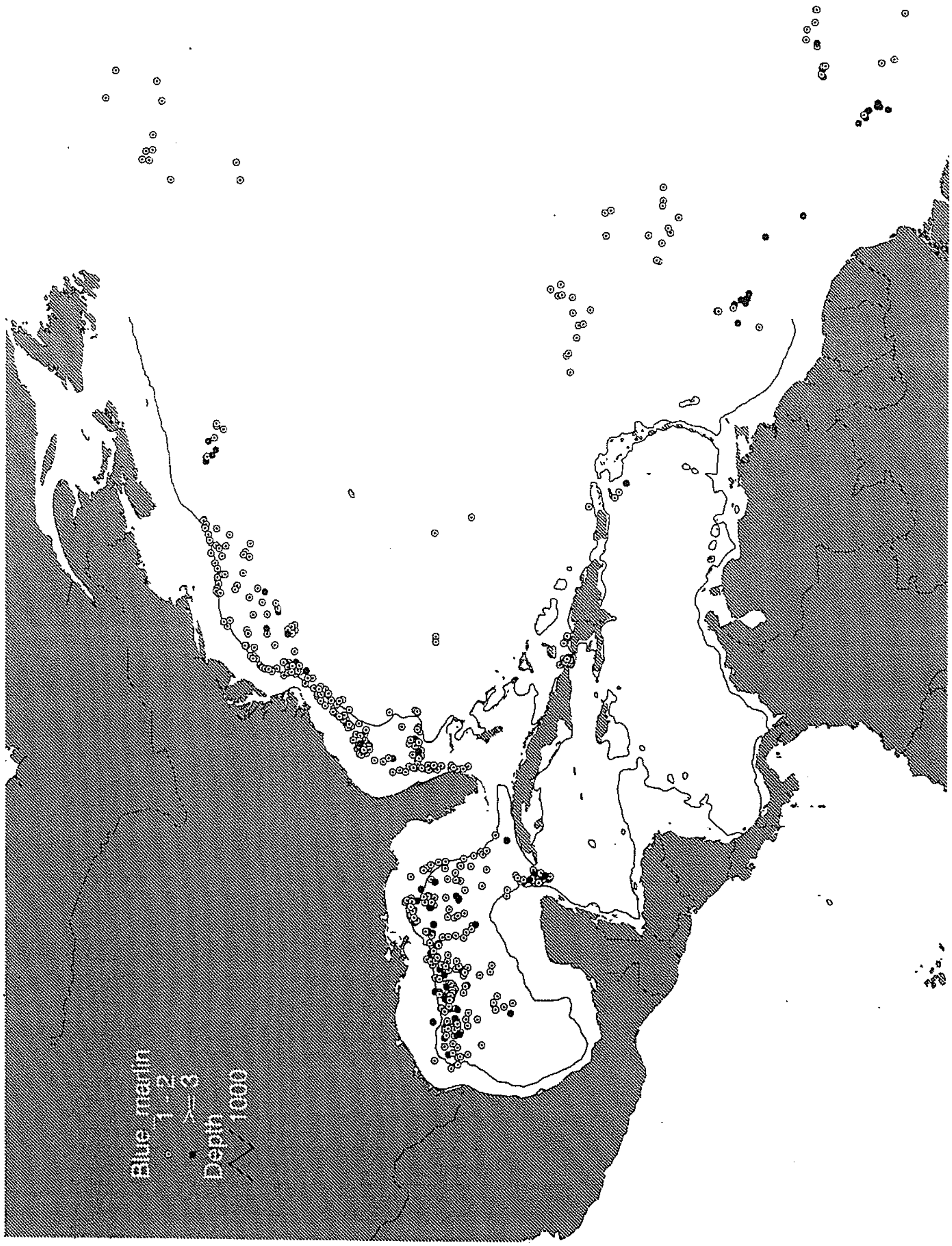


FIGURE 37. Blue marlin distribution and nominal catch rates.

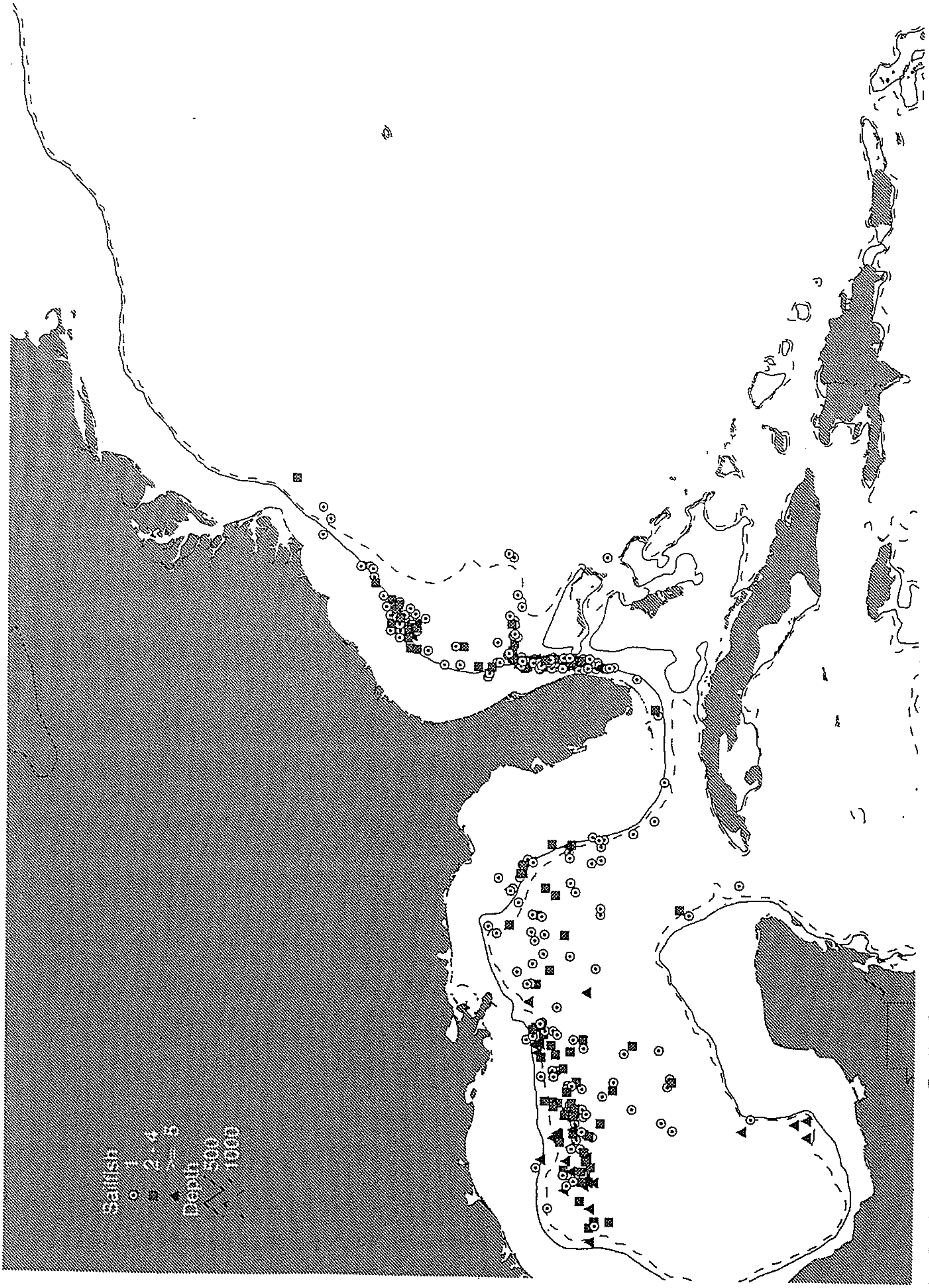


FIGURE 38. Sailfish distribution and nominal catch rates.

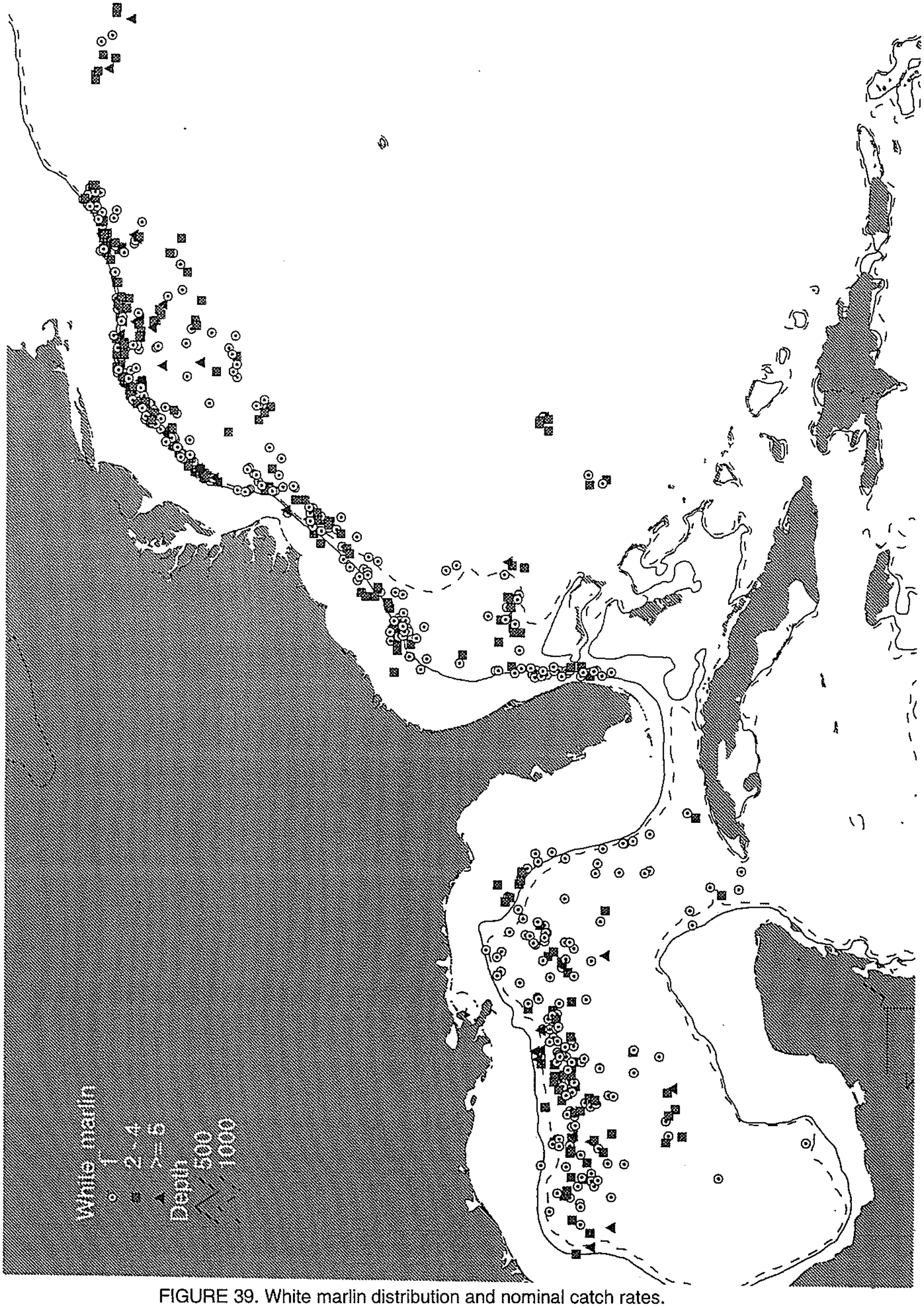


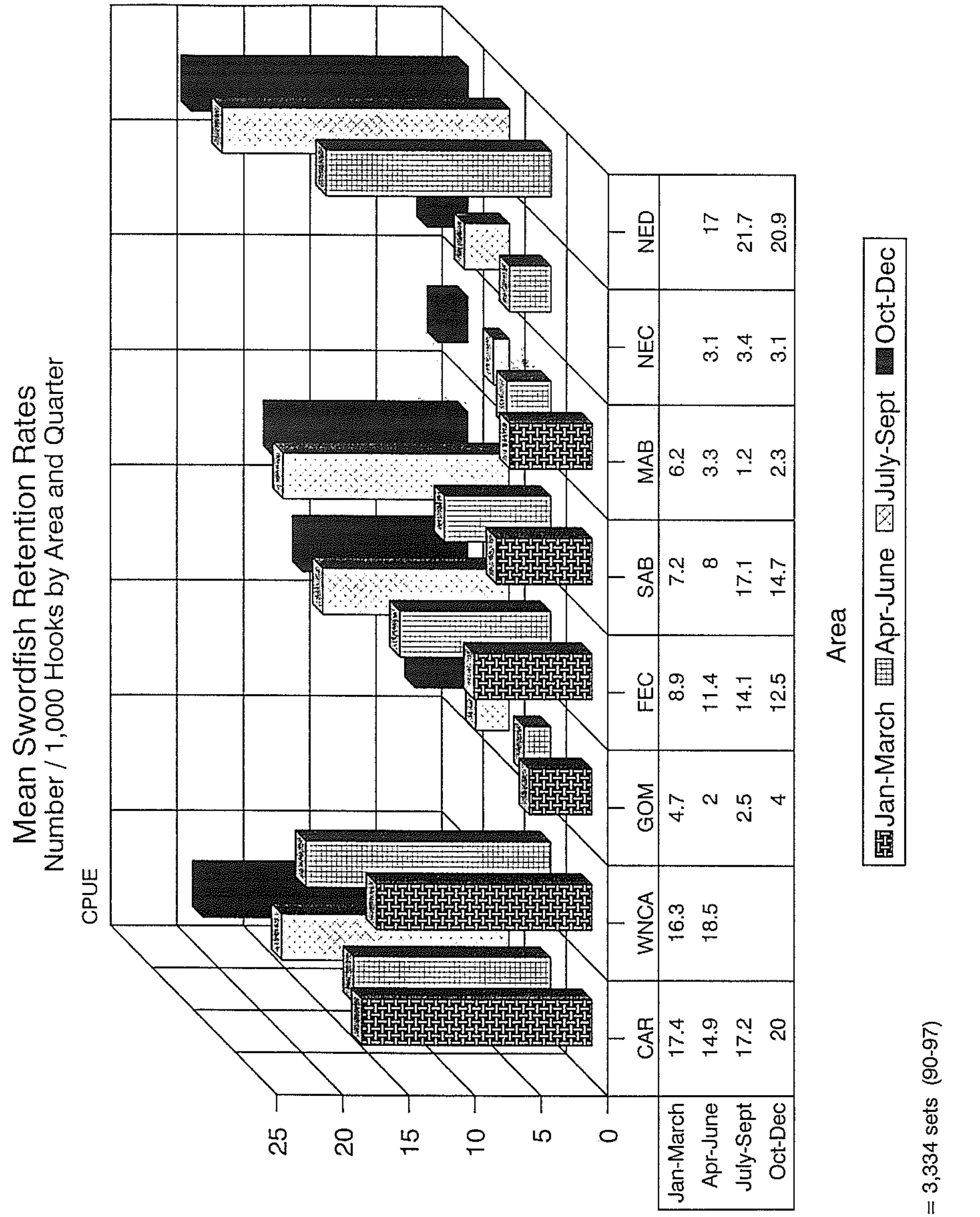
FIGURE 39. White marlin distribution and nominal catch rates.

CASE STUDY - SWORDFISH

Swordfish discards are an obvious priority concern for the longline fishery. Of the 3,334 sets observed 14.2% had no swordfish catch (473 sets), 16.3% (542 sets) caught swordfish but they were all discarded, and 13.6% (452 sets) caught swordfish and had no discards. While the sets that retained all swordfish (no discards) are widely distributed, sets that discarded all the swordfish that were caught tend to be more prevalent in areas with effort targeting tuna (GOM and MAB). The remaining 56% of the observed sets caught and discarded varying numbers of swordfish.

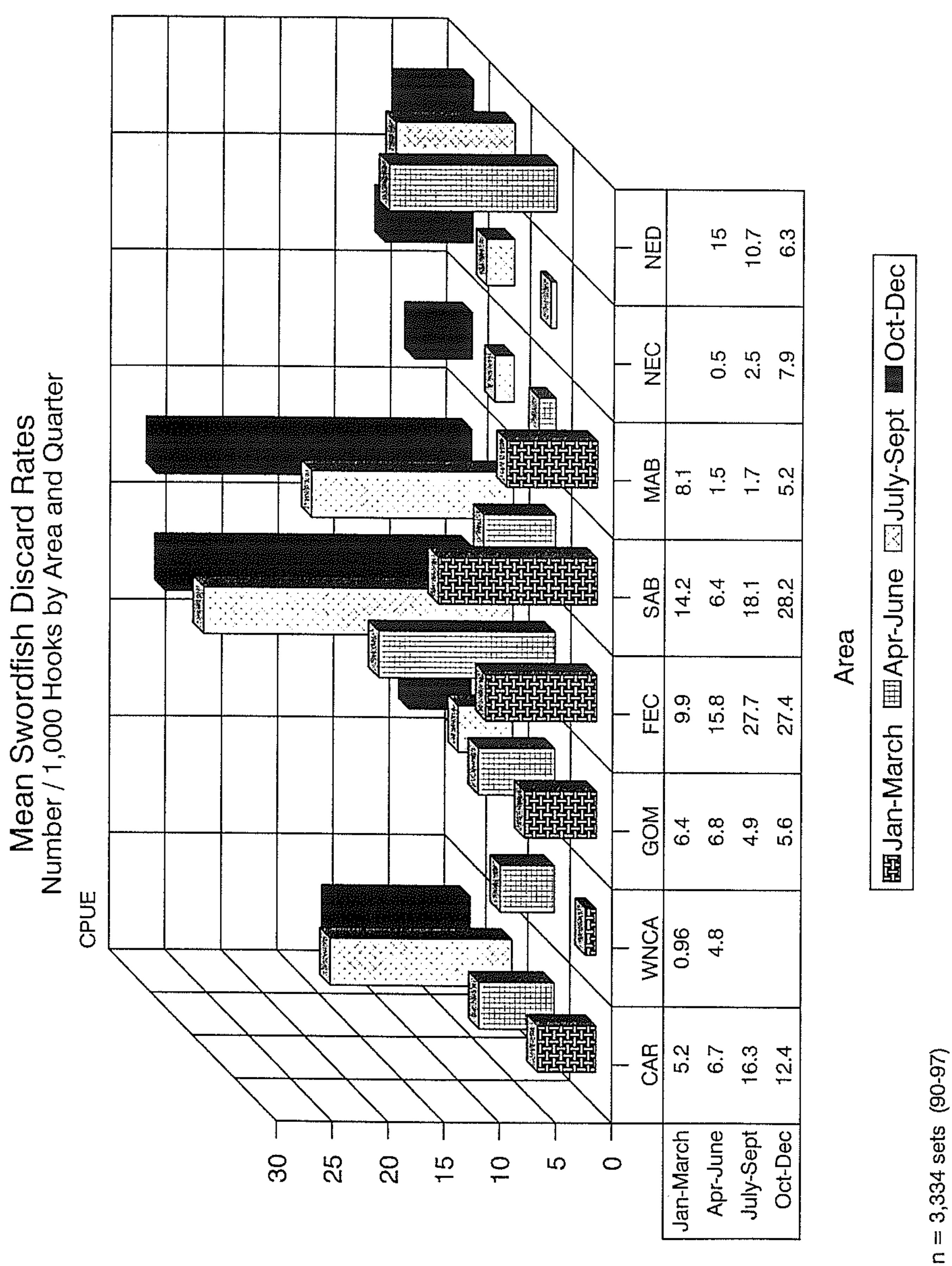
While previous sections have provided average regional swordfish catch and discard rates in the text, graphical comparisons of swordfish retention (kept) and discard rates (numbers per 1,000 hooks) by area and quarter are provided in Figure 40 and Figure 41. Catch rates rather than numbers are provided to standardize for differences in average set size between areas. Both retention and discard rates vary by area and quarter. Figure 42 identifies the location of sets that had discard rates of four or less swordfish per 1,000 hooks and sets with discard rates of 5 to 11 swordfish per 1,000 hooks. Figure 43 identifies the sets that had discard rates of 12 or more swordfish per 1,000 hooks. In the NED area, the high discard sets (12 or more per 1,000 hooks) are associated with mean average set temperatures of 68^0 F compared to low discard sets (four or fewer swordfish per 1,000 hooks) with mean average set temperatures of 62^0 F. It is important to emphasize that temperature regimes vary and that it is often not just an absolute temperature but the relative position of the gear (berth) between warm and cold sides of the dominant thermal gradient in the area that will dramatically influence swordfish size and discard rates. In the cluster of high discard CPUE sets along the 1,000-meter contour in the NEC area (20 sets) 50% occurred in December. The remaining sets were recorded during the fall months with average water temperatures that were generally 70^0 F or colder. These low average temperatures may reflect sets along sharp thermal gradients where swordfish of a variety of sizes are being forced southward by seasonal cooling of the shelf and slope water. The cluster of high discard sets in the MAB (48 sets) also consisted primarily of fall and winter months, 22 in January, 10 in October and eight in November. Average water temperatures below 75^0 F were again predominant. For sets with discard rates of 18 or more swordfish, 66% occurred with sea surface temperatures between 78^0 F and 87^0 F, and most of these were located south of 35^0 N.

As indicated within the regional text, the interplay of targeting strategies (day versus night sets), water depths, and gear rigs may contribute to high swordfish discard rates. In some areas high swordfish discards appeared to be associated with depth strata shallower than 500 meters. Targeting depths beyond 500 meters with nighttime fishing may significantly reduce these discards. In the GOM, MAB, and NEC areas fishermen targeting tuna may be able to reduce swordfish discards by focusing more effort in depths beyond 500 to 1,000 meters with deeper catenary rigs unless the colder side of the dominant thermal edge is available. In the MAB and particularly NEC area, this may significantly increase bigeye tuna catch rates. In all areas where swordfish are targeted, attempts to avoid water temperatures greater than 78^0F, either by moving or fishing with more hooks between floats or longer gangion and dropper lines, should reduce swordfish discards. The deeper fishing strategy may be especially helpful if the fishermen's berth is offshore of the dominate front.



	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Jan-March	17.4	16.3	4.7	8.9	7.2	6.2		
Apr-June	14.9	18.5	2	11.4	8	3.3	3.1	17
July-Sept	17.2		2.5	14.1	17.1	1.2	3.4	21.7
Oct-Dec	20		4	12.5	14.7	2.3	3.1	20.9

FIGURE 40. Mean swordfish retention rates by area and quarter.



	CAR	WNCA	GOM	FEC	SAB	MAB	NEC	NED
Jan-March	5.2	0.96	6.4	9.9	14.2	8.1		
Apr-June	6.7	4.8	6.8	15.8	6.4	1.5	0.5	15
July-Sept	16.3		4.9	27.7	18.1	1.7	2.5	10.7
Oct-Dec	12.4		5.6	27.4	28.2	5.2	7.9	6.3

FIGURE 41. Mean swordfish discard rates by area and quarter.

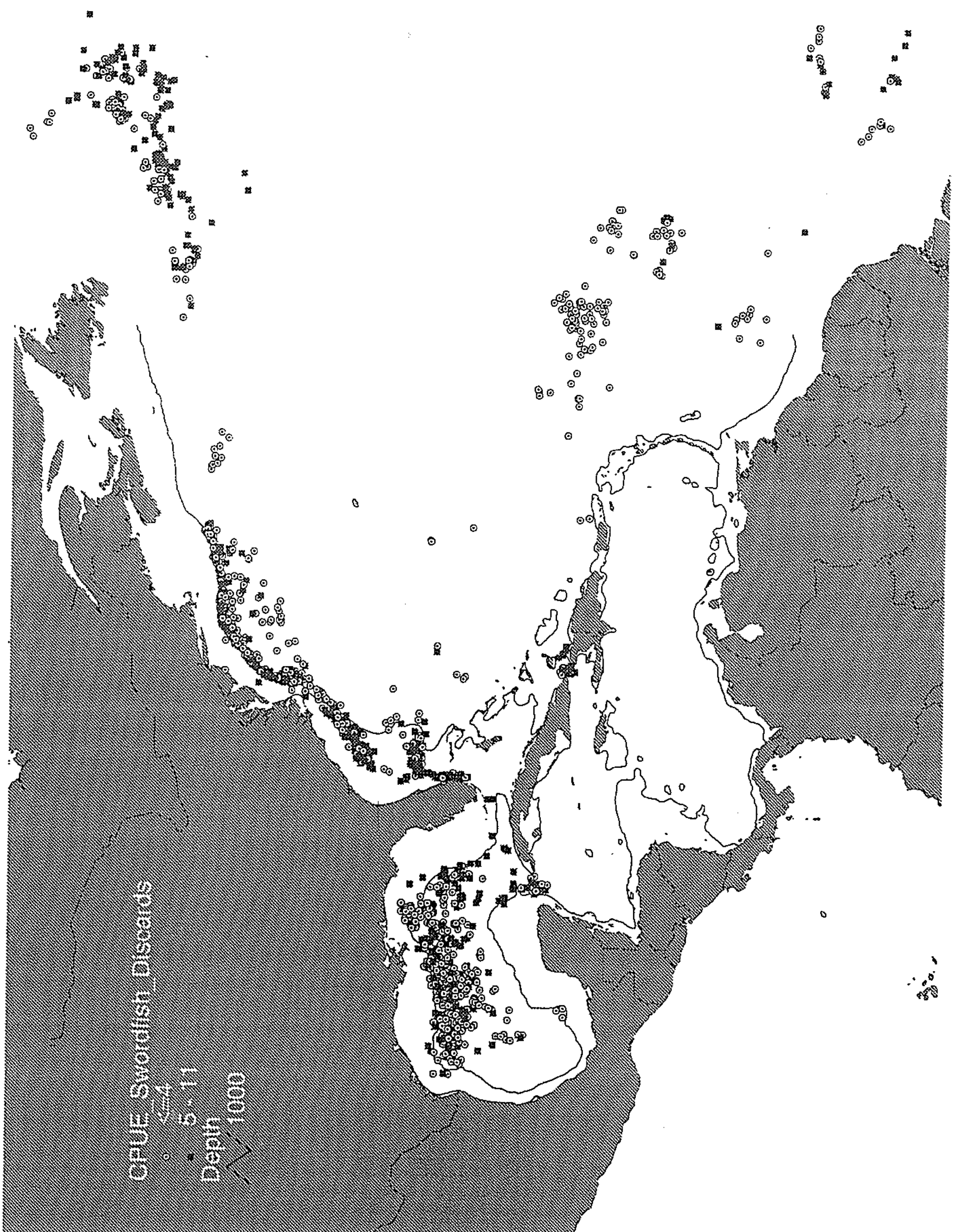


FIGURE 42. Location of sets with swordfish discard rates of four or less and five to 11 swordfish per 1,000 hooks.

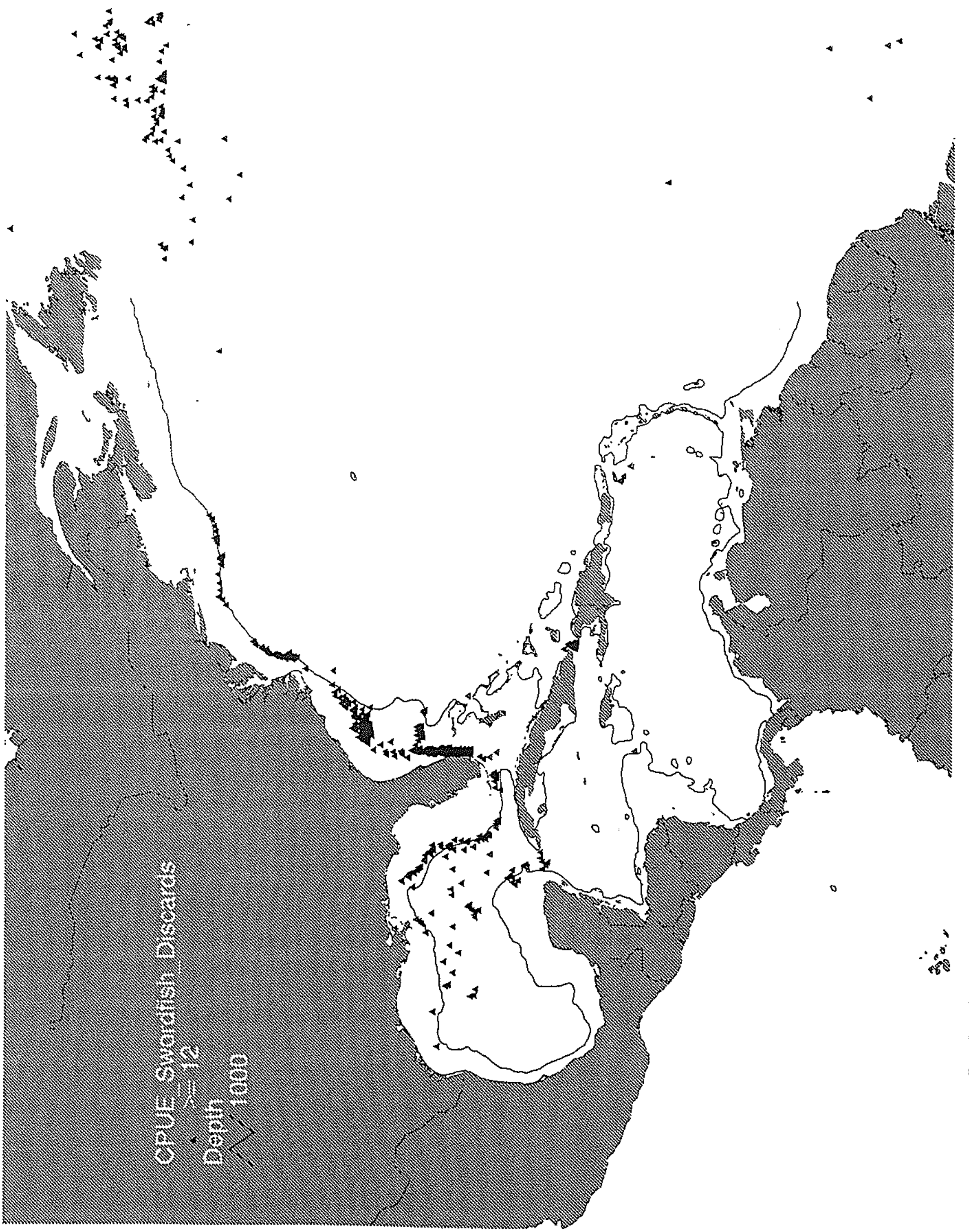


FIGURE 43. Location of sets with swordfish discard rates of 12 or more swordfish per 1,000 hooks.