8.0 DESCRIPTION OF THE FISHERY

8.1 Description of Stocks

8.1.1 Species and Its Distribution

The swordfish, *Xiphias gladius*, is considered to be a single species over its worldwide distribution from about 45° N to 45° S in all tropical, subtropical and temperate seas (Palko et al., 1979).

8.1.2 Life History

8.1.2.1 Reproduction

Swordfish are heterosexual; however, there are no known external characteristics to separate males from females although several authors indicate that larger swordfish are usually females (Palko et al., 1979).

Age at first spawning was reported to be five or six years (Yabe et al., 1959), which is at an orbit-fork length of approximately 160 to 185 cm (64 to 74 in). This is equivalent to a lower jaw-fork length of 219 to 245 cm (86 to 97 in) calculated as follows (S. Berkeley, Research Associate, Univ. Miami, Miami, FL; pers. comm.): lower jaw-fork length = 13.39 + 1.053 (orbit-fork length). Estimates of sexual maturity off the southeast coast of the U.S. are 21 kg (49.3 lb) for males and 74 kg (163.1 lb) for females (Berkeley, 1981).

Fecundity estimates range from 3 million to 16 million eggs produced per spawning (Fish, 1926; Yabe et al., 1959; Uchiyama and Shomura, 1974). Recent estimates of fecundity, defined as the number of ova in the most advanced mode within the ovary, for south Florida waters ranged from 1.41 to 4.20 million (Berkeley, 1981). Further, fecundity is related to weight by the following linear relationship:

$$F = 0.77 + 0.0144\ W$$

where:

F = fecundity in millions of ova

W = whole weight of female in kg

Mean relative fecundity, defined as ova per gram body weight, was 17.8 (Bekeley, 1981).

In comparison, a 33 kg (72.8 lb) sailfish was estimated to release up to 4.8 million ova per season (Jolley, 1977). Jolley (1977) also observed that fecundity increased with fish size. Fecundity estimates for white marlin between 26.8 and 37.2 kg (59 and 82 lb) ranged from 3.8 to 10.5 million eggs (Baglin, 1979).

Historical evidence exists to classify swordfish as single, multiple or partial spawners (Yabe et al., 1959; Cavaliere, 1963; Uchiyama and Shomura, 1974). However, recent data from south Florida waters indicate that they are multiple spawners and that fecundity estimates will need to be modified to include less developed ova for a final estimate that will significantly increase initial estimates (Berkeley, 1981) which included only more developed ova (S. Berkeley, Research Associate, Univ. Miami, Miami, FL; pers. comm.).

Fertilization is external (Palko et al., 1979). The peak spawning period in the western North Atlantic Ocean occurs during late fall and winter months (Arata, 1954; Taning, 1955; Tibbo and Lauzier, 1969; Markle, 1974; Fahay, 1975; Grall et al., 1981); however, larvae have been collected in the northwest Atlantic in all months which suggests a longer spawning period. Three main spawning areas were reported by Grall et al. (1981): (1) Straits of Yucatan, (2) Straits of Florida, and (3) near the Lesser Antilles.

8.1.2.2 Age and Growth

Adult swordfish lack scales which makes scale-reading for age assessment impossible. However, Artuz (1963) reported rings on the dorsal fin spines of Sea of Marmara swordfish which he thought to be annual marks. More recently Berkeley and Houde (1980, 1981) have used anal fin spines to age swordfish. They found a good linear relationship between fork length and fin spine radius of 439 swordfish (1981 paper):

$$L = 58.50 + 23.90\,S \qquad r = .94$$

where:

L = lower jaw-fork length (cm)

S = anal fin spine radius (mm)

r = correlation coefficient

There was no difference by sex reported. Berkeley and Houde (1981) then used the relationship and the measured radii to each presumed annulus to back calculate mean lengths at each annulus. They then converted lengths to weight (from their length-weight relationship) in order to estimate mean weights at different ages:

	Males		Females		Both Sexes	
Age*	Whole weight (kg)+	Dressed weight** (kg)	Whole weight (kg)	Dressed weight** (kg)	Whole weight (kg)	Dressed weight** (kg)
I	12.0	9.0	9.8	7.4	10.9	8.2
II	21.6	16.2	19.6	14.7	20.6	15.5
III	31.7	23.8	33.3	25.0	32.5	24.4
IV	41.8	31.4	49.2	36.9	45.5	34.1
V	54.4	40.8	67.2	50.4	60.8	45.6
VI	66.7	50.0	85.3	64.0	76.0	57.0
VII	75.8	56.9	109.1	81.8	92.4	69.3
VIII	82.0	61.5	135.9	101.9	109.0	81.8

* Older fish (XI+) have been aged but due to small sample sizes they were excluded from this analysis.
** Dressed wt = 0.75 whole weight
\+ 1 kg = 2.2046 lb

Beckett (1974) estimated a faster growth rate using modal size frequencies and tagging data from the Canadian fishery. Females grow faster than males after age II and attain a larger size (Berkeley and Houde, 1980, 1981). The largest female aged in Florida weighed more than 300 kg (661.4 lb; 11 years old) while the largest males were less than 140 kg (308.6 lb).

Berkeley and Houde (1981) fitted the von Bertalanffy growth model to their fork length at age data for males, females and sexes combined; the result is shown in Figure 8-1. The equations, population parameter estimates, back-calculated lengths at age, as well as predicted lengths at age are presented in Table 8-1.

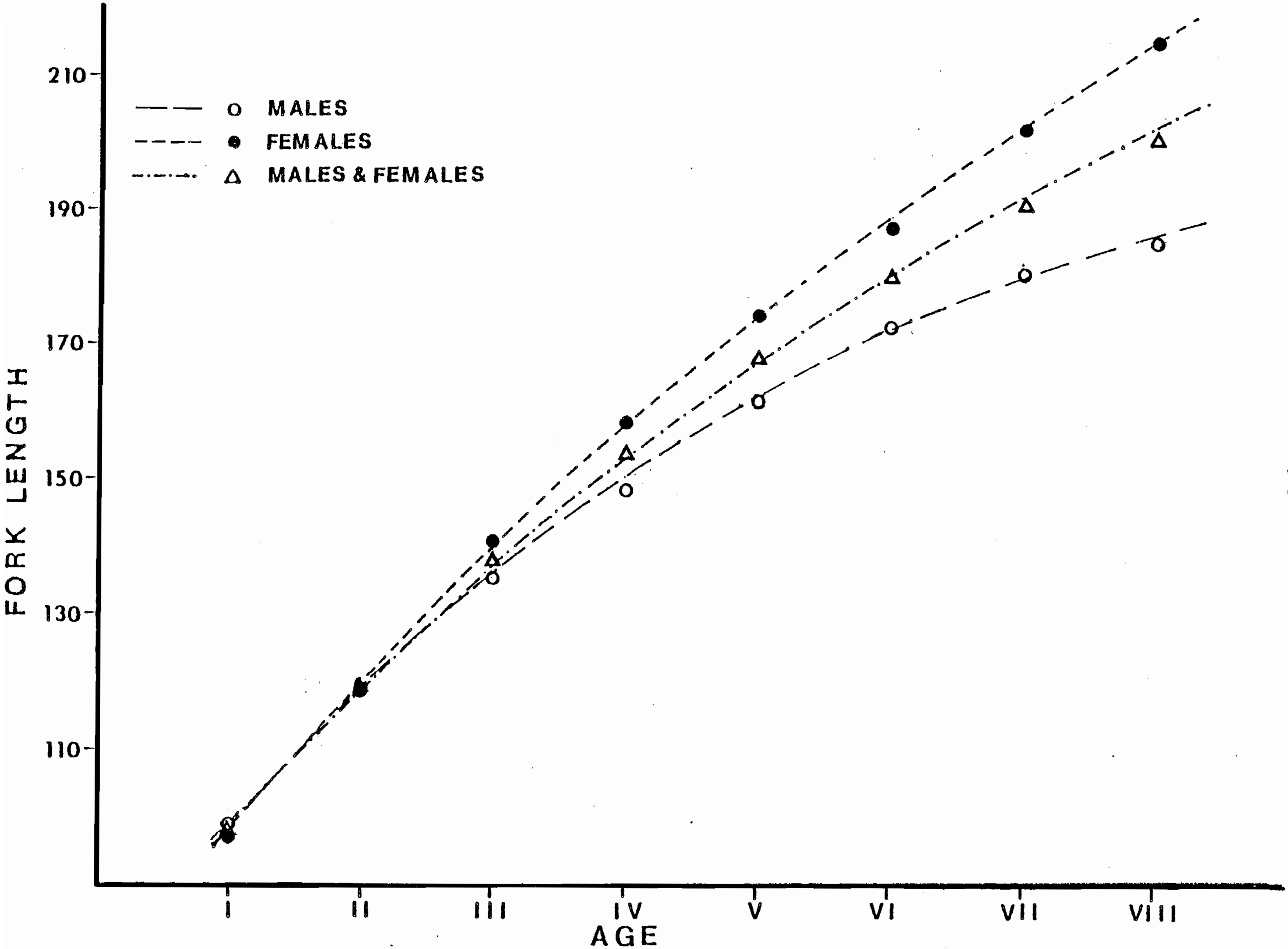

Figure 8-1. The relationship between fork length (cm) and age (yr) for swordfish landed in south Florida. The data points are back-calculated lengths at annuli for males, females and both sexes combined. Curves are based on the von Bertalanffy models fitted to these data. (Source: Berkeley and Houde, 1981).

Table 8-1. Mean back-calculated lengths at age and those predicted by the von Bertalanffy model for swordfish landed in south Florida. Equations and parameter estimates are also given. (Source: Berkeley and Houde, 1981)

	Males and Females Fork length (cm)		Males Fork length (cm)		Females Fork length (cm)	
Age	Back-calculated	Predicted from von Bertalanffy growth equation	Back-calculated	Predicted from von Bertalanffy growth equation	Back-calculated	Predicted from von Bertalanffy growth equation
1	98.02	99.46	98.86	97.24	97.17	97.99
2	119.55	119.23	119.27	118.50	119.83	119.85
3	138.16	137.02	135.41	136.00	140.90	139.73
4	153.59	153.03	148.54	150.40	158.63	157.82
5	168.01	167.45	161.55	162.25	174.46	174.28
6	180.20	180.42	172.79	172.01	187.60	189.25
7	191.29	192.09	180.38	180.03	202.19	202.87
8	200.67	202.59	185.12	186.64	216.22	215.25
	$L_t = 297.10(1-e^{-0.1054(t + 2.8672)})$		$L_t = 217.36(1-e^{-0.1948(t + 2.0444)})$		$L_t = 340.04(1-e^{-0.09465(t + 2.5912)})$	
	$L_{oo} = 297.10$		$L_{oo} = 217.36$		$L_{oo} = 340.04$	
	$K = 0.1054$		$K = 0.1948$		$K = 0.09465$	
	$t_o = -2.8672$		$t_o = -2.0444$		$t_o = -2.5912$	

The differential growth rates of the sexes is clearly shown by growth coefficients of 0.1948 and 0.09465 for males and females respectively. In addition, the sexes do not occur in equal proportions in the Florida fishery where males predominate by a ratio of 1.7:1 (Berkeley and Houde, 1981). They further report that the sex ratio changes with age:

Age	I	II	III	IV	V	VI	VII	VIII
Males:Females	2.1:1	1.5:1	3.6:1	2.6:1	1.9:1	1.2:1	1.1:1	0.4:1

Note that, after age 8, females represent virtually 100 percent of the catch. Due to the unequal sex ratios, Berkeley and Houde (1981) averaged estimates of length and weight at age for males and females to give the combined estimates.

Beardsley (1978) summarized Caddy's (1977) estimated parameters of the von Bertalanffy growth equation based upon swordfish taken by Canadian fishermen in the northwest Atlantic. These are:

L_{∞} = 144 in (365 cm)

K = 0.230

Calculated ages at size from Caddy (1976):

Age (years)	Fork Length[1]		Round Weight	
	in	cm	lb	kg
1	19.7-35.4	50-90	3.1-19.4	1.4-8.8
2	39.4-43.3	100-110	26.9-36.1	12.2-16.4
3	47.2-59.0	120-150	47.3-94.4	21.4-42.9
4	63.0-70.9	160-180	115.3-166.1	52.2-75.3
5	74.8-86.6	190-220	196.4-309.2	89.1-140.3
6+	90.6+	230+	354.9+	160.9+

1. Tip of lower jaw to caudal fork.

In 1977 and 1978, Beardsley et al. (1978) sampled 168 swordfish caught at night by recreational fishermen using rod and reel which ranged in size from 3.5 kg (7.72 lb) to 268.0 kg (590.83 lb). They reported the following length-weight relationship:

$$Y = -5.5669 + 3.2994\,L \qquad \text{std. error} = .0370$$
$$N = 166$$

where:

$Y = \log_{10}$ weight

$L = \log_{10}$ lower jaw - fork length

Berkeley and Houde (1981) observed fish in age classes 0 to XI in south Florida longline catches; however, more than 50 percent of the catch was composed of ages 1-4 (Figure 8-2). It is important to note that while landings are dominated by catches of relatively small swordfish (mostly males), the fishery depends to a large extent on the relatively infrequent catches of large, older and mostly female fish, which contributed greater than 30 percent of the landings by weight in the Florida Strait's fishery (Berkeley and Houde, 1980) and bring a higher price per pound than smaller fish.

8.1.2.3 Mortality

Total mortality rates were estimated by Berkeley and Houde (1981) using several methods.* The maximum likelihood estimate (Robson and Chapman, 1961) of the instantaneous mortality coefficients with .95 confidence limits for males, females and both sexes combined are:

Males	Females	Both Sexes
$Z = 0.44 \pm 0.07$	$Z = 0.33 \pm 0.06$	$Z = 0.40 \pm 0.05$
N = 245	N = 139	N = 391

A second estimate based on the expected relationship between growth and annual mortality rate (Beverton and Holt, 1956) was obtained from:

$$Z = \frac{K(L_{\infty} - \bar{l})}{\bar{l} - l'}$$

where: l' = length of smallest fish fully represented in the sample

$\bar{l}$ = average length of all fish above l'

*Portions are taken directly from Berkeley and Houde (1981).

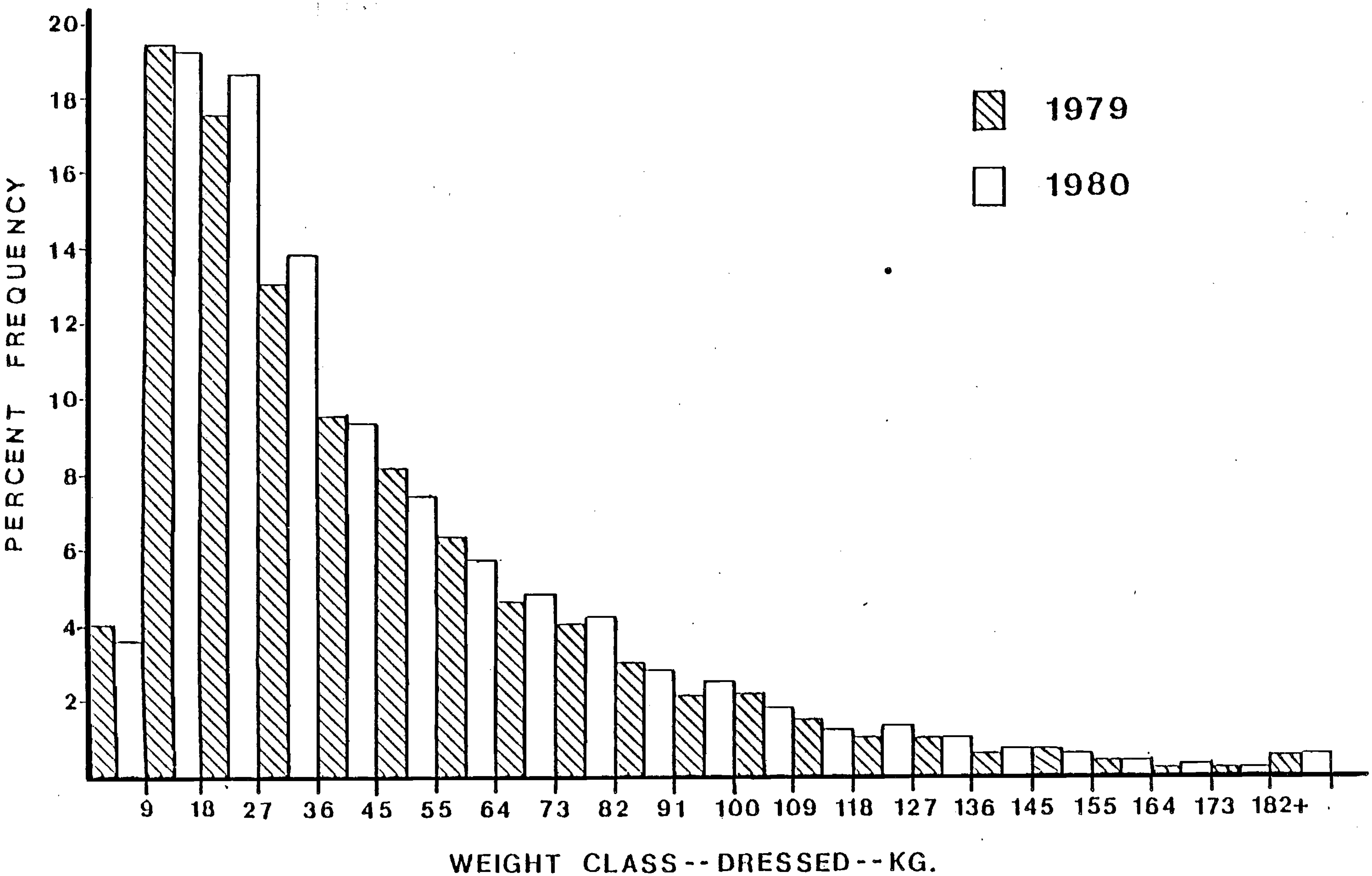

Figure 8-2. The weight-frequency distribution for 7,985 swordfish landed by longline in Florida in 1979 and 14,837 swordfish landed in 1980. Dressed weight equals whole weight X 0.75. (Source: Berkeley and Houde, 1981).

The results are:

Males		Females		Both Sexes	
Z	= 0.36	Z	= 0.26	Z	= 0.35
l'	= 127 cm	l'	= 130 cm	l'	= 130 cm
$\bar{l}$	= 158.7 cm	$\bar{l}$	= 185.6 cm	$\bar{l}$	= 168.6 cm
L_{oo}	= 217.4 cm	L_{oo}	= 340.0 cm	L_{oo}	= 297.1 cm
K	= 0.1948	K	= 0.0946	K	= 0.1054

A third estimate was obtained from (Ssentongo and Larkin, 1973):

$$Z = K \left(\frac{n}{n+1}\right) \left(\frac{1}{\bar{y} - y_c}\right)$$

where:

$$n = \text{sample size}$$

$$\bar{y} = -\ln \left(1 - \frac{\bar{l}}{L_{oo}}\right)$$

$$y_c = -\ln \left(1 - \frac{l'}{L_{oo}}\right)$$

Using the above values for L_{oo}, l', $\bar{l}$, and K, the results are:

Males		Females		Both Sexes	
Z	= 0.45	Z	= 0.30	Z	= 0.40
n	= 190	n	= 98	n	= 291

Natural mortality rates were estimated from the equation relating natural mortality, growth parameters and mean environmental temperature determined empirically by Pauly (1980):

$$\log M = 0.1228 - 0.1912 \log L_{oo} + 0.7485 \log K + 0.2391 \log T$$

Assuming a mean environmental temperature of 15°C (59° F) and using the previously determined growth parameters the estimates are:

Males		Females		Both Sexes	
M	= 0.27	M	= 0.14	M	= 0.16

Caddy (1977), using the Beverton and Holt (1956) method, reported that total mortality was in the range of 0.12 to 0.65 for the Canadian harpoon fishery and 0.16 to 0.58 for the Canadian longline fishery.

Using Berkeley and Houde's (1981) mortality data, the estimated fishing mortality coefficient (F) was in the range 0.10-0.24 for males, 0.13-0.25 for females and 0.19-0.29 for both sexes.

8.1.3 Ecological Relationships

8.1.3.1 Larval Ecology

Swordfish larvae can be recognized by their long snouts, prominent supraorbital crest, heavily pigmented, elongate bodies. When longer than 8.0 mm (0.32 in) they possess one or more rows of spinous scales on each side of the dorsal and anal fins, with those along the anal fins continuing forward to the level of the pectoral fin (Matsumoto and Kazama, 1974; Palko et al., 1979).

Swordfish larvae occur at or near the surface during all times of the day and thus do not exhibit negative phototrophism (Arata, 1954; Taning, 1955; Tibbo and Lauzier, 1969; Markle, 1974). Larvae feed on fish larvae and copepod crustaceans. The juveniles and adults of tunas, dolphins, mackerels, snake mackerels, flying fish and billfish are predators of swordfish during their early life. Cannibalism may result in scattered distribution of swordfish larvae (Arata, 1954). Larval growth rates range from 0.6 to 2.0 mm (0.02-0.08 in) per day (Arata, 1954; Taning, 1955; Yabe et al., 1959; Tibbo and Lauzier, 1969; Uchiyama and Shomura, 1974).

Berkeley and Houde (1980) recently completed a search of published and unpublished data to examine areas of occurrence of larval swordfish and to relate their occurrence to spawning distributions and abundances of adults. Their conclusions were as follows:

"Larval swordfish have been collected in every month of the year from the western North Atlantic Ocean. Of 545 larval observations, 207 (38 percent) were from the Gulf of Mexico and 64 (11.7 percent) were from the Caribbean Sea. The majority of larvae (75.1 percent) were collected when surface temperature ranged from 25°-30°C. Most Gulf of Mexico swordfish larvae (76.8 percent) were collected when surface temperatures exceeded 27°C, indicating that a spawning population is present in the Gulf throughout the summer months. In the Caribbean Sea most swordfish larvae have been collected from November to February, when surface temperature was less than 27°C, indicating a possible distributional shift toward the tropics by adults during the winter months. In areas other than the Gulf or Caribbean most larvae (75.8 percent) were collected from May to November. For the entire western North Atlantic, 22.5 percent of larvae were collected from January to April, 48.7 percent from May to August and 28.8 percent from September to December. Concentrations of larval occurrences were noted in the east-central Gulf of Mexico, Straits of Florida and eastern Caribbean Sea. Because sampling effort among areas is not known, we cannot be certain that those areas are the most important spawning sites, but they are areas where significant spawning occurs in the western North Atlantic."

Grall et al. (1981) studied the distribution and seasonality of a collection of 961 larval swordfish from the Atlantic, Pacific and Indian Oceans. In the western North Atlantic larvae were most abundant in the Straits of Florida, Straits of Yucatan and the Lesser Antilles. They appeared most numerous during the fall and winter (September-February) but were found year round. Also, most were collected in the open ocean greater than 200 m (656.2 ft).

8.1.3.2 Food-Chain Relationships

Swordfish are opportunistic feeders that feed on fish and squid from the surface to about 914.4 m (3,000 ft) In adults, the vertical distribution (see Section 8.1.3.4.1) of these upper trophic level predators is believed to be linked to the diurnal movements of their prey, and the species composition of prey found in the stomach of swordfish varies with the geographical area, depth and concentration of forage (Bigelow and Schroeder, 1953; Yabe et al., 1959; Tibbo et al., 1961; Squire, 1962; Cavaliere, 1963; Guitart-Manday, 1964; Scott and Tibbo, 1968; Maksimov, 1969; Ovchinnikov, 1970; Torin 1971; Beckett, 1974.)

Stomach contents from 65 swordfish caught in the Florida Straits were analyzed (Toll and Hess, 1981) and results indicated that cephalopods account for over 90 percent of total weight of contents in 69 percent of the stomachs. Of these, squid (Illex) were the most important prey items. The diversity of prey found in this study confirms the postulated opportunistic feeding strategy of swordfish. "Analysis of the vertical distribution of cephalopod prey indicated that swordfish feeding is most concentrated in epipelagic and upper mesopelagic waters" (Toll and Hess, 1981). The following fish were found in the stomachs: (1) scads

(Trachurus spp.); (2) round herring (Etrumeus teres); (3) scombrids; (4) various pelagic midwater species; and (5) demersal parrotfishes (family Scaridae). Berkeley (1981) noted that prey such as parrotfishes implies that swordfish must make feeding forays onto reef areas of relatively shallow depth.

In temperate waters of the Atlantic, swordfish have been seen basking on the surface; this is thought to facilitate digestion (Palko et al., 1979). There is evidence from stomach contents (Tibbo et al., 1961) and the long dorso-ventrally compressed sword (Scott and Tibbo, 1968) that indicate swordfish may use their sword to kill prey. Swordfish have been observed stunning small fish in a school and later swallowing these fish (Goode, 1883). Scott and Tibbo (1968) found fish in swordfish stomachs that may have been cut with the sword, damaging the muscle and vertebral column. The use of their sword to kill prey was verified by Toll and Hess (1981).

8.1.3.3 Predator-Prey Relationships

The intraspecific and interspecific relationships of swordfish are not well understood (Parin, 1967, 1968; Ovchinnikov, 1970). Swordfish do not school like tunas and are generally classified as solitary fish. Tibbo et al. (1961) and Ovchinnikov (1970) reported that nonspawning swordfish are commonly separated by a distance of about 9.1 to 91.4 m (30 to 300 ft). However, catch rates at depth (i.e., where several fish are hooked in a particular location during a short period of time) suggest that swordfish may aggregate to some degree.

Swordfish are hydrodynamically adapted for swift swimming (Ovchinnikov, 1968; Aleev, 1971; Kozlov, 1973; Magnuson, 1973). It is speed that contributes both to protection from predators and to their own predatory habits. Adult swordfish are often found with tunas, dolphins (coryphaena), sharks, and other billfishes seeking similar food. The effect this competition for similar food has on survival is probably minimal since swordfish can feed on a variety of foods from the surface to the ocean floor, can travel between tropical and temperate waters, and are opportunistic predators (Palko et al., 1979).

The competing species are predatory upon larval and juvenile swordfish. Dolphin frequently contain juvenile swordfish in their stomachs. In addition, larval and juvenile swordfish are cannibalistic. Swordfish compete with sharks (Parin, 1967) for food, and are preyed on by sharks (Tibbo et al., 1961; Parin, 1970), sperm and killer whales (Tibbo et al., 1961). Swordfish attacks on sharks have been documented (Maksimov, 1968).

Although sea lampreys (Petromyzon marinus) have been reported by Tibbo et al. (1961) and Guitart-Manday (1964) to attack migrating swordfish, leaving open wounds, it is probably the cookie-cutter shark (Isistius) that causes these nonserious wounds (Jones, 1971; Amorim et al., 1979).

The following parasites were found in swordfish off Cuba (Guitart-Manday, 1964): Ascaris incurva in virtually all stomachs, unidentified Hirudinea in the stomach, unidentified cestoda attached to the outer walls of the stomach, and an unidentified ectoparasitic Pennella deep in the subcutaneous muscular tissue. Many nematodes are found in the stomachs and two kinds of cestodes are found in the intestinal tract (Artuz, 1963). Palko et al. (1979) reported that swordfish in the Sea of Marmara frequently have a parasitic copepod (Pennellidae) attached.

8.1.3.4 Movement Patterns

8.1.3.4.1 Horizontal and Vertical Movements

Sonic tagging experiments in the eastern Pacific and western Atlantic Oceans (Carey and Robison, 1977) showed the following movement. During the day swordfish generally stayed inshore and at dusk headed seaward moving up and down through large depth ranges. They fed offshore near the surface (1.8-12.8 m; 1-7 fm) after sunset and returned inshore but at a greater depth, 91.4-128.0 m (50-70 fm), at sunrise. Larger swordfish did not move inshore; instead, they set up a meandering course seaward.

Movements of swordfish were studied using acoustic telemetry to record water temperature and depth of swordfish in the Pacific and Atlantic by Carey and Robison (1980, 1981). Swordfish seem to follow a diel cycle of movement between an inshore bank during the day and deep water offshore at night. Swordfish showed definite vertical movement in response to light, moving down in the water column during daylight hours and moving up near the surface at night. The maximum depth in their experiments was 617 m (2,024.4 ft); however, Church (1968) sighted a swordfish at 654 m (2,145.8 ft) from a submarine and another submarine (Alvin) was attacked by a swordfish while on the bottom at 610 m (Zarudski, 1967).

The fact that longline vessels fish a narrow range along the edge of the continental shelf is well known and supported by numerous advisory panel representatives. This was further confirmed by Berkeley (1981) where aerial overflights by Florida's Department of Natural Resources indicated an average density of 0.11 boats per nautical mile. These flights were conducted along the shelf edge and support a narrow horizontal distribution for swordfish.

8.1.3.4.2. Migrations

It is generally believed that swordfish migrate from subtropical western North Atlantic Ocean waters to temperate waters along the edge of the continental shelf during spring, after spawning, and then return south in late autumn and winter to complete the cycle (Tibbo et al., 1961; Guitart-Manday, 1964; Ovchinnikov, 1969, 1970; Beckett, 1971, 1974; Caddy, 1976). These contentions are supported in part by a long-range (3,057.1 km; 1,900 mi) tag return from the Gulf of Mexico to Georges Bank and two tag returns from Georges Bank to Florida (over 1,000 mi). Seasonal north-south migration patterns of swordfish are reported for the eastern North Atlantic Ocean and Black Sea and in the Pacific Ocean (Nakamura et al., 1951; Yabe et al., 1959; Svetovidov, 1964; Ovchinnikov, 1970; Ueyanagi et al., 1970). This is further supported by researchers that report a seasonal aggregation along the edge of the continental shelf and on offshore banks in higher latitudes (Rich, 1947; Wise and Davis, 1973). Ovchinnikov (1969) considers it possible for swordfish and other billfishes to migrate between the North Atlantic Ocean and the Indian Ocean past the Cape of Good Hope. It is not known if all life history stages of swordfish migrate or if migration occurs across the North Atlantic or from the southern Caribbean Sea or South Atlantic Ocean north into regional waters.

8.1.4 Stock Definition

There are no reports in the scientific literature which define the stock structure for swordfish in the Atlantic Ocean. However, investigators have commented on stock structure which may be pertinent to this description of the fishery. Beardsley (1978) reported that the catch-per-unit of effort (CPUE) from the Japanese longline fishery in the Atlantic

Ocean shows three seasonal concentrations of broadbills: (1) northwest coast of Africa, just outside the Mediterranean Sea, in November and December; (2) northwest Atlantic Ocean in July and again in September through October; (3) South Atlantic, off the coasts of Uruguay and Argentina, from April through October. The swordfish fisheries off the northwest coast of Africa (and Mediterranean Sea) are discussed by Cordiero (1958), Artuz (1963), Amorim et al. (1979), and Rey and Gonzales-Garces (1979), while those from the southwest Atlantic are reported on by Amorim et al. (1979). The fisheries of the northwest Atlantic are discussed by Goode (1883, 1884), Rich (1947), Tibbo et al. (1961), Torin and Volkov (1971), and Caddy (1976).

Although Beardsley (1978) reported that the existence of three fairly distinct concentrations located thousands of miles apart suggests that there are three populations of swordfish in the Atlantic, Japanese CPUE data provide inconclusive evidence for the purposes of defining unit stocks, because considerable intermixing is possible among the three areas. In addition, the Japanese longline fishery targets tunas, not swordfish; thus the CPUE could be misleading. It should be cautioned that swordfish are taken in almost all areas of the Atlantic Ocean and there does not appear to be a clear-cut dividing line between the groups. However, the Japanese longline catch data presented by Wise and Davis (1973) seem to reveal a general drift of North Atlantic swordfish from the equatorial region to northern waters in the northern summer, and a corresponding drift of South Atlantic swordfish toward the south during the southern summer. Wise and Davis (1973) pointed out, however, that Japanese CPUE data for swordfish stock definition may yield invalid interpretations because swordfish harvested* by Japanese longlines were caught in a fishery which is primarily a daytime fishery although fishing activities extend into nighttime hours, whereas the U.S. fishery is primarily a nighttime fishery.

*The Japanese CPUE data discussed in Beardsley (1978), were derived from catch data before the Preliminary Management Plan for billfishes (Federal Register January 27, 1978) was effected.

In the New England Region, commercial catches of swordfish are taken from June to December in continental shelf and slope waters, primarily from Georges and Grand Banks to offshore Gulf Stream waters (Tibbo et al., 1961; Wilson and Bartlett, 1967; Wise and Davis, 1973; Beckett, 1974; Caddy, 1976). Originally, the fishery from Cape Hatteras north had been a year-round fishery (M. R. Bartlett, Advisory Panel, pers. comm.). It is generally believed that each year swordfish migrate south along the continental shelf edge from New England in late autumn, to spawn in tropical waters and then return north in the spring. A swordfish tagged in the Gulf of Mexico was recovered in New England and two swordfish tagged on Georges Bank were recovered in Florida. In regard to stock definition, Beckett (1974) and Caddy (1976) suggest that two races exist within the seasonal northwest Atlantic fishery. However, Beckett (pers. comm.) reported that the data needed for conclusive stock identification were lacking.

In the South Atlantic and Gulf of Mexico regions, swordfish are caught in continental shelf and slope waters of all states (North Carolina to South Florida, including the Florida Keys, and from the west coast of Florida to Texas). It is generally believed that the maximum number of swordfish in Cuba occur during the winter and early spring (during spawning), while a minimum number occur in summer and fall (Guitart-Manday, 1964).

There are no means to clearly separate stocks based on life histories, distributions, morphological characteristics, catch and effort records, parasites or diseases, and biochemical characteristics, as has been done in the past on other species (Lackey and Herbert, 1977). However, data which are available concerning the incidence of infection of swordfish from various parts of the Atlantic with specific parasite species is of interest in analyzing the stock structure question. The copepod _Pennella filosa_ was reported by Tibbo et al. (1961), Guitart-Manday (1964) and Amorim et al. (1979) to occur on swordfish in New England, Cuban and Spanish waters, respectively, whereas _P. filosa_, _P. instructa_ and _P. orthagorisci_ were reported by Amorim et al. (1979) to occur in Brazilian waters.

The Task Force for Reevaluation and Analysis of Available Data Concerning Billfishes and Sharks chose to consider two different swordfish stock possibilities in their preliminary assessment of the status of western North Atlantic billfish and shark stocks. They were (1) a "North Atlantic" stock with removals from FAO statistical areas 21, 27, 31 and 34, (Figure 8-3) and (2) a "Western North Atlantic" stock with removals coming from FAO statistical areas 21 and 31 (Figure 8-3).

Since swordfish are among the most widely distributed species and apparently have a very complex migratory pattern, a completely definitive answer on the problem of stock structure will not be forthcoming. However, there appears to be sufficient information to adequately assess stock structure for management purposes. The weight of circumstantial evidence presently available strongly suggests separate northeastern and northwestern Atlantic stocks of swordfish:*

1. At least 40-50 swordfish tagged in the western North Atlantic have been recaptured.+ Most recaptures have been within a relatively short distance from the point of release. There has been at least one swordfish tagged in the Gulf of Mexico and recaptured in waters off New England. One fish tagged off Norfolk Canyon was recaptured off Cape Canaveral, Florida. There have been no swordfish tagged in the western North Pacific recaptured in the eastern Atlantic despite an intensive fishery there.

2. Japanese swordfish catches incidental to their directed high seas tuna longline fishery show no particular trend relative to changes in catches or effort in the Canadian or U.S. swordfish fishery. After a few years of intensive swordfish longlining, the Canadians experienced a dramatic decline in CPUE and mean size. This was not reflected in the Japanese swordfish incidental catch.

3. Swordfish landings in the northeast Atlantic and Mediterranean do not appear to have fluctuated with major changes in landings in the northwest Atlantic. Within a few years after the swordfish fishery began its rapid expansion in Florida and the Gulf of Mexico, there was a decline

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*Source: S. Berkeley, Research Associate, Univ. Miami, Miami, FL; pers. comm.)
+The shark tagger annual summaries. Various years. NOAA, NMFS.

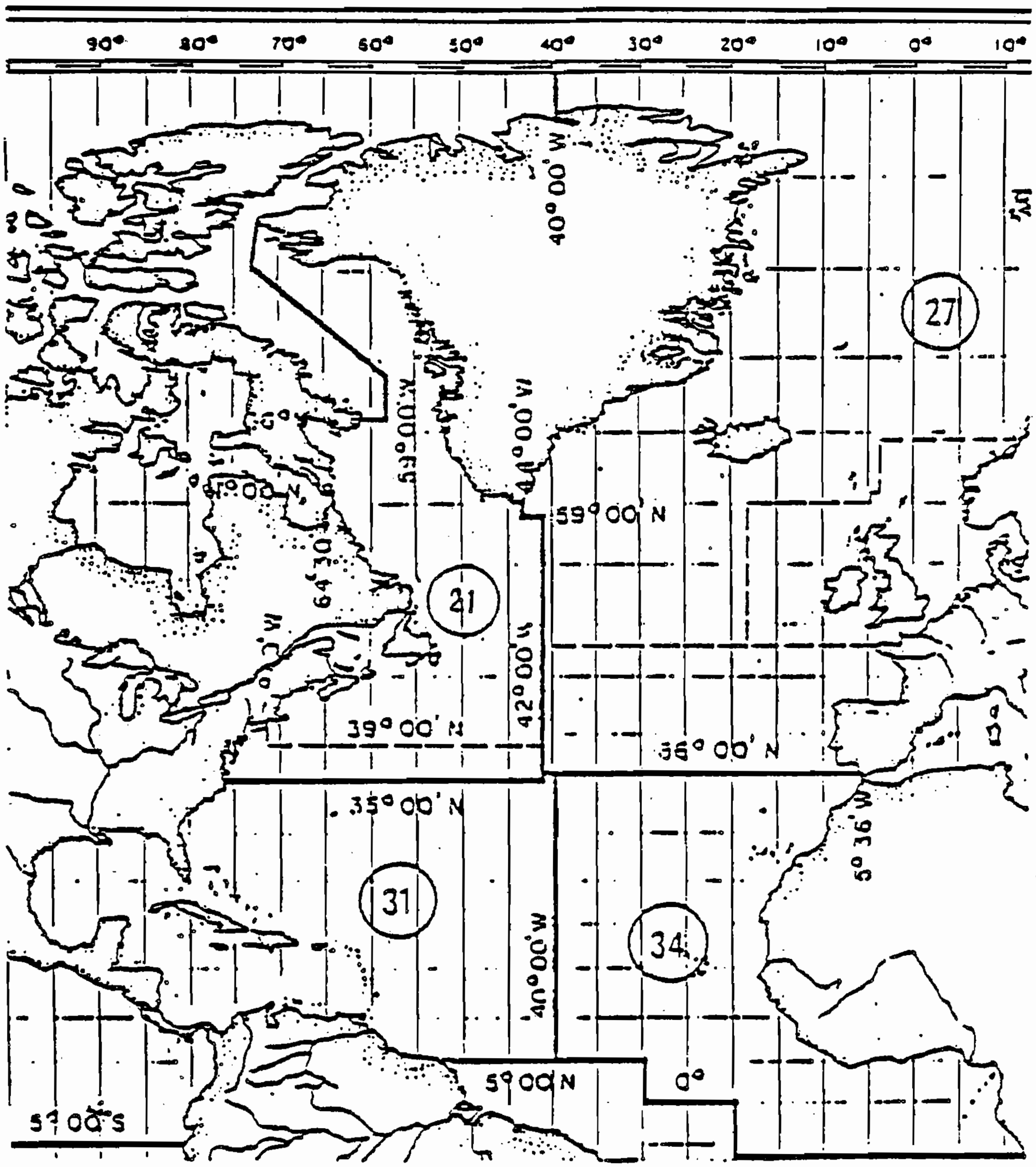


Figure 8-3. FAO statistical reporting areas (21 = NWAtl.; 27 = NE Atl.; 31 = WC Atl.; 34 = EC Atl.; Western NAtl=21,31; Eastern NAtl=27,34; Source: FAO Yearbook of Fishery Statistics)

in CPUE in the New England area suggesting that the two areas may be fishing the same stock. However, a concurrent decline in catch or CPUE did not occur in the Mediterranean or eastern Atlantic suggesting that these fish constitute a separate stock. Figure 8-4 shows the reported swordfish landings for the eastern and western Atlantic between 1960 and 1979. In 1963, the Canadian and American swordfish fisheries changed from a harpoon fishery to a primarily longline fishery. Reported landings which had previously fluctuated around 2,500 MT (5.5 million lb) increased to 8,500 MT (18.7 million lb) and then stabilized at around 5,000 MT (11.0 million lb) until 1970. In the eastern Atlantic, during this period, reported landings increased steadily from approximately 2,000 MT (4.4 million lb) to over 7,000 MT (15.4 million lb). In 1971, the mercury issue caused the fishery in Canada and the U.S. to collapse. Although reported landings are known to underestimate actual landings after 1971, there certainly was a substantial reduction in catches and effort during this time. Between 1971 and 1978, the allowable level of mercury remained at 0.5 ppm and effort remained relatively low. Reported landings during this period remained at less than 2,000 MT (4.4 million lb). In the eastern Atlantic, reported landings fluctuated between 7,000 and 9,000 MT (15.4-19.9 million lb). In 1975, the swordfish fishery began expanding in the western North Atlantic, primarily in Florida, South Carolina and the Gulf of Mexico. In addition, the raising of the allowable mercury concentration from 0.5 to 1.0 ppm in 1978 encouraged additional effort in the fishery and landings in the western North Atlantic began increasing. During this time period, landings in the eastern North Atlantic continued to fluctuate between 7,500 and 9,000 MT (16.5-19.9 million lb).

Although these data give no indication of change in landings relative to effort, they do indicate that changes in landings in one area are independent of changes in the other area, thus suggesting separate stocks.

4. Spawning information compiled by Beardsley (1977) indicates that ripe females and larvae occur in the Straits of Messina in the Mediterranean from April through September, and in the Caribbean and throughout the Florida Straits from January through October. Although larvae have been found over a wide area in the tropical and sub-tropical Atlantic, concentrated spawning activity in these widely divergent areas suggests two separate spawning stocks.

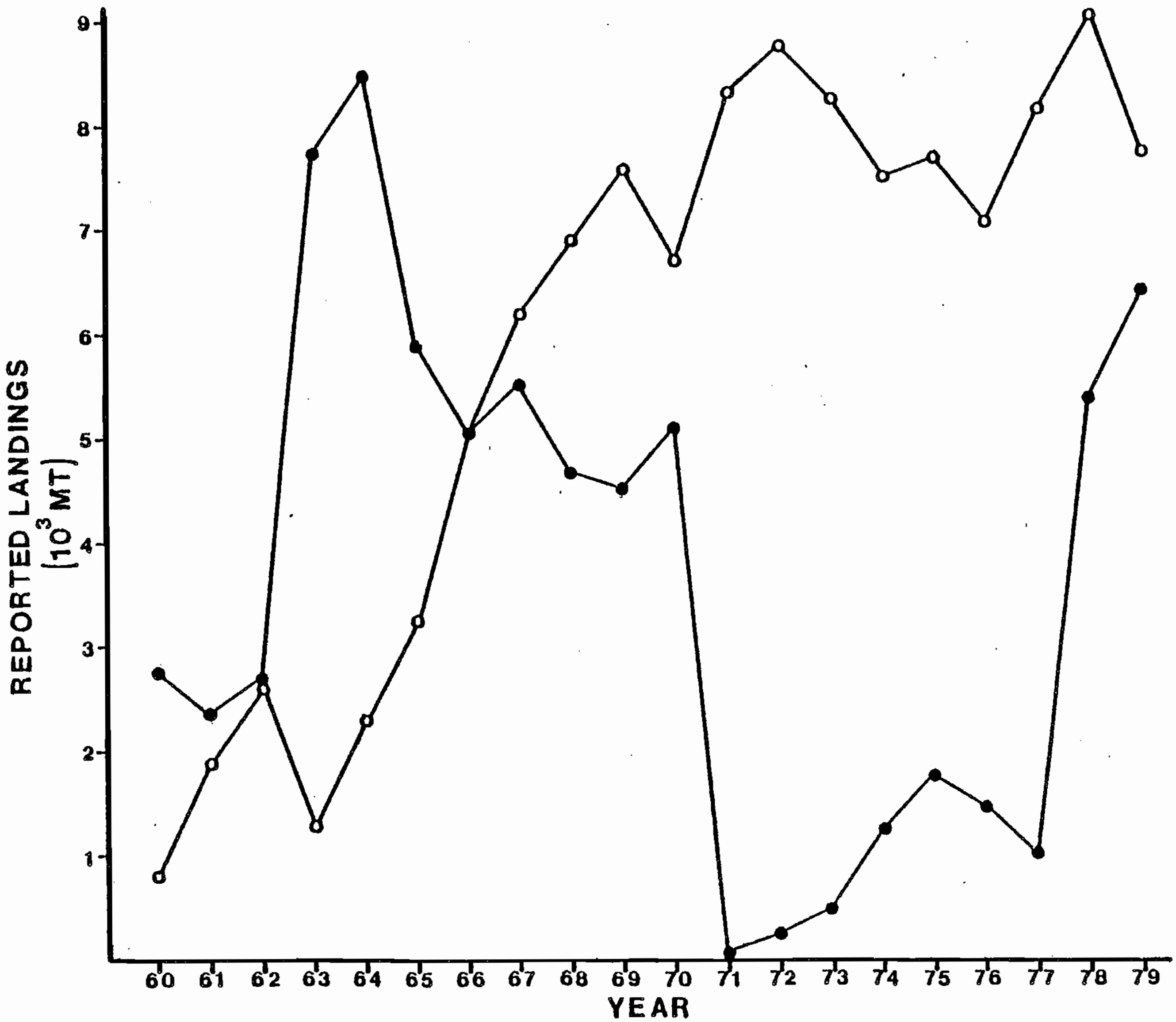


Figure 8-4. Reported swordfish landings from the western North Atlantic (●——●) and eastern North Atlantic (including the Mediterranean Sea) (O——O), 1960-1979. (Source: S. A. Berkeley, Research Associate, Univ. Miami, Miami, FL; pers. comm.)

Although some mixing between the eastern and western Atlantic is not only possible but almost certainly does occur, it appears that this exchange is insignificant from the standpoint of management. With over 40 tag recaptures, some out as long as nine years, if there were a significant amount of interchange between the eastern and western Atlantic, we would expect at least a small number of tag returns from the eastern Atlantic.

Landings in the U.S. and Canadian fisheries in the western North Atlantic and landings in the eastern North Atlantic and Mediterranean appear to fluctuate independently. The occurrence of spawning adults and larvae at the same time of year in very widely separated areas also suggests separate stocks. Although not definitive, the evidence to date supports the two stock hypothesis in the North Atlantic.

8.1.5 Abundance, Historical Fluctuations, and Present Condition

Appendix A contains the historical (1960-1976) U.S. swordfish catch and effort data by Council area. The swordfish catch by distance caught off U.S. shores is shown in Table 8-2. During 1976 (the most recent data) 68.6 percent of the catch originated in the FCZ, 30.9 percent from international waters and only 0.5 percent from State territorial seas.

During the first few years of longlining, total U.S. and Canadian catches increased dramatically (Figure 8-5). Combined landings reached a high of over 8,000 metric tons (MT) (17.6 million lb) round weight in 1963 and then dropped off and stabilized at between 4,500 and 5,000 MT (9.9 and 11.0 million lb) round weight on an annual basis up until 1970 (Caddy, 1976). The Canadian fishery accounted for 80 to 95 percent of the total catch during this period.

Catches by the Canadian fleet after 1962 included many more small fish (Beckett, 1971). This trend toward the landing of smaller fish continued until the Canadian fishery closed in 1971 and is illustrated by a comparison of the size distribution of Canadian landed fish in 1963 and in 1970, as shown in Figure 8-6. The average dressed weight of fish landed each year prior to 1963 was approximately 90.7 kg (200 lb); in 1970, it was approximately 45.4 kg (100 lb) (Beckett, 1971). This change in size composition of the catch has been partially attributed by Beckett (1971) and Caddy (1976) to a change to longline gear (harpoon gear is selective for

Table 8-2. Swordfish catch by distance caught off U.S. shores. (Source: Fish. Stat. of the U.S., 1960-76.)

	Distance Caught off U. S. Shores				International Waters (Includes Catch off Foreign Coasts)		TOTAL	
	0 - 3 miles		3 - 200 miles					
	'000 lb	'000 $	'000 lb	'000 $	'000 lb	'000 $	'000 lb	'000 $
1960	-	-	-	-	-	-	-	-
1961	400				(1)			
1962	900				(1)			
1963	2,000				300			
1964	1,400				100			
1965	732				56			
1966	817				38			
1967	0				0			
1968	373				16			
1969	0				0			
1970	0				0			
1971	0				0			
1972	0				0			
1973	0				0			
1974(2)	-	-	-	-	-	-	-	-
1975	174	279	3,588	5,043	1,697	1,909	5,459	7,231
1976	20	48	2,974	4,452	1,341	1,809	4,335	6,309

(1) Less than 50

(2) First year landings were divided as indicated in heading. For years 1960-1973 the headings were "Waters off U.S. Coasts" and "High Seas off Foreign Coasts"; values were not recorded prior to 1974.

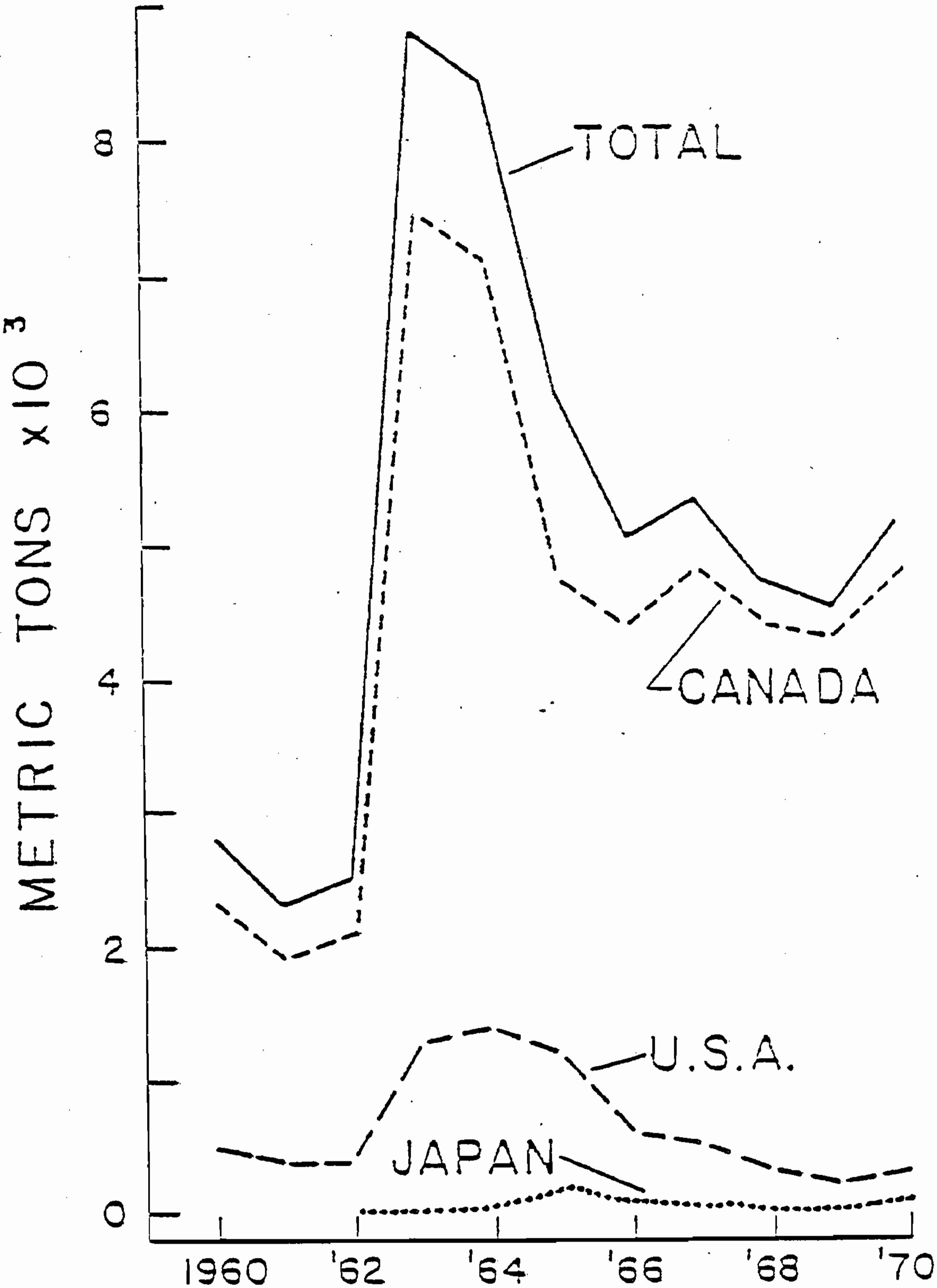


Figure 8-5. Annual landings of swordfish in the western North Atlantic by Canada, the U.S. and Japan north of 25°N and West of 50°W. (Source: Caddy, 1976). (Note: Catches from the western and eastern North Atlantic for the years 1970-1979 are shown in Tables 8-28 and 8-29.)

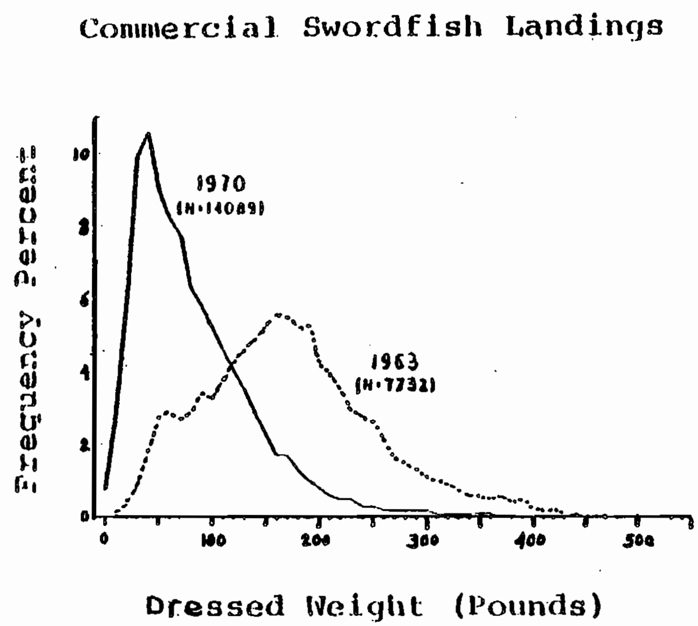


Figure 8-6. Size distribution of swordfish landed in Canada in 1963 and 1970. (Source: Beckett, 1974).

large, female fish), as well as to the expansion of the fishing grounds into warmer waters where more small fish are taken, and to the extension of the season.

Caddy (1976) has reported that, from 1962 to 1970, harpoon landings in the Canadian fishery decreased in response to a decrease in effort. Longline landings, however, rose to 5,218 MT (11.5 million lb) dressed weight (6,888 MT or 15.2 million lb round weight) in 1964, at an effort level of somewhat less than 6 million hooks, and then fell to a fairly constant level of around 3,500 MT (7.7 million lb) dressed weight (4,600 MT or 10.1 million lb round weight), although fishing effort had increased to between 6 million and 7 million hooks (Caddy, 1976). The data from Caddy (1976), shown in Table 8-3, demonstrate that catch per unit effort expressed in terms of metric tons per thousand hooks decreased between 1962 and 1970. Data on the Canadian swordfish longline fishery, reported by Beckett (1971) and presented in Table 8-4, showed that catch-per-unit effort expressed as number of fish caught per 100 hooks decreased slightly from 1964 to 1969, and average fish weight decreased. Caddy (1976) notes that Canadian longline landings were maintained at a level of around 4,500 MT (9.9 million lb) round weight annually from 1965 to 1970 only by increased fishing effort and continual expansion into new fishing areas.

In 1970, the size of the Canadian longline fleet was estimated at 58 to 67 vessels, with an annual effort of 6 million to 7 million hooks (Caddy, 1976). In 1971, however, the commercial Canadian swordfish fishery collapsed as a result of mercury restrictions (Beckett, 1971). In 1979, Canada reopened its swordfish fishery with a quota of 3,000 MT (6.6 million lb).

A Japanese pelagic longline fishery targeting tuna has existed in the Atlantic since 1956 (Fox, 1971). During the period from 1966 to 1971, Japan reported annual landings of swordfish (as an incidental catch) from this fishery of around 1,800 MT (4.0 million lb) (ICCAT). In contrast to the Canadian and U.S. longline fishery, which were mostly night fisheries, the Japanese fishery was predominantly a daytime longline fishery, with lines being set before dawn and taken in after dark.

Table 8-3. Catch and effort statistics for the Canadian harpoon and longline fisheries, 1950-1970. (Source: Caddy, 1976)

Year	Landings Dressed Weight (Metric Tons) Harp.	Landings Dressed Weight (Metric Tons) LL	Total	Effort: Days Fished Harp.	Effort: Days Fished LL	Effort: Estimated Effort Thousand Hooks LL	Catch-per-unit effort (metric tons): Catch Per Days Fished Harp.	Catch-per-unit effort (metric tons): Catch Per Days Fished LL	Catch-per-unit effort (metric tons): Catch Per Thousand Hooks LL
1950	978	-	978	3,195	-	-	0.31	-	-
1951	1,154	-	1,154	3,773	-	-	0.31	-	-
1952	1,432	-	1,432	4,614	-	-	0.31	-	-
1953	1,508	-	1,508	5,186	-	-	0.29	-	-
1954	1,952	-	1,952	6,122	-	-	0.32	-	-
1955	2,062	-	2,062	4,841	-	-	0.43	-	-
1956	2,092	-	2,092	4,760	-	-	0.44	-	-
1957	2,350	-	2,350	5,345	-	-	0.44	-	-
1958	2,439	-	2,439	7,112	-	-	0.34	-	-
1959	3,040	-	3,040	6,204	-	-	0.49	-	-
1960	1,764	-	1,764	5,260	-	-	0.34	-	-
1961	1,450	-	1,450	4,756	-	-	0.30	-	-
1962	1,349	236	1,585	4,424	325	114	0.30	0.73	2.07
1963	606	5,062	5,668	1,260	3,807	2,323	0.48	1.33	2.18
1964	160	5,218	5,378	572	6,653	5,786	0.28	0.78	0.90
1965	393	3,148	3,541	945	4,707	5,335	0.42	0.67	0.59
1966	532	2,826	3,358	1,249	4,325	4,740	0.43	0.65	0.60
1967	197	3,435	3,632	700	4,102	4,930	0.28	0.84	0.70
1968	39	3,289	3,328	186	5,261	6,735	0.21	0.63	0.49
1969	82	3,143	3,225	225	4,971	6,769	0.36	0.63	0.46
1970	83	3,553	3,636	218	4,263	6,216	0.38	0.83	0.57

Note: Harp. = harpoon
LL = Longline

Table 8-4. Average fish size and catch-per-unit effort for the Canadian swordfish longline fishery 1963-1969. (Source: Beckett,1971.)

Year	Log Coverage[a] %	Number of Fish[a]	Hooks[a] (thousands)	Catch per 100 Hooks	Average Weight
1963	41	74,911	2,117	2.88	168.1
1964	39	79,604	5,225	1.36	148.9
1965	58	54,882	4,746	0.98	142.24
1966	57	54,323	4,646	1.00	136.3
1967	57	70,245	4,770	1.36	114.0
1968	58	70,588	6,739	1.03	104.0
1969	58	71,350	6,735	1.03	99.9

a. Estimated on ratio of landings covered by log books to total landings.

8.1.5.1 Swordfish Fishery Under Mercury Restrictions of 0.5 PPM (1971-1978)

In 1971, the swordfish fishery suffered a severe setback when the FDA issued interim guidelines limiting the permissible amount of mercury in swordfish to 0.5 ppm. The FDA guideline of 0.5 ppm was based on the following assumptions:

1. Daily mercury intake of 300 mcg/day is the threshold level at which clinical effects are observed in humans
2. 10 fold safety factor sets the threshold at 30 mcg/day
3. All mercury consumed is through seafood
4. All mercury consumed is methyl mercury
5. Average consumption of seafood is 60 g/day

Therefore, mercury consumption in all seafood cannot exceed 0.5 ppm to ensure mercury consumption is not above 30 mcg/day.

Few swordfish pass the 0.5 ppm criteria. Based on a regression of mercury concentration by size fish (381 Canadian samples from the Consumer Risk Simulation Model, NOAA, NMFS-SEFC-18) the following are predicted mercury concentrations by size fish:

AVERAGE SIZE (POUNDS WHOLE WEIGHT)	MERCURY CONCENTRATION (PPM)
66.65	0.6676
133.30	1.0190
199.95	1.3049
266.00	1.5552
333.25	1.7819
399.90	1.9916
466.55	2.1882

Some U.S. fishermen continued to fish for swordfish during the 0.5 ppm mercury restrictions. The clandestine operation of this fishery was fostered by the fishermen's fear that they would suffer economic loss if their catches were impounded by the FDA for sampling and testing. Commercial catch statistics after 1970 are inaccurate since landings went unreported for the most part. Because of the secrecy surrounding the fishery during this time, there is very little known about the extent of U.S. involvement and actual amounts of catches.

Caddy (1976) reported that there is some evidence from Canadian research cruises conducted in 1975 that average fish size and CPUE have increased in Northwestern Atlantic waters since 1970. He attributed this finding to diminished Canadian fishing effort in that area. A comparison of CPUE and dressed weight of swordfish landed in 1970 and 1975, from Caddy (1976), is given in Table 8-5.

In 1976 Cuban Americans began a localized longline fishery for swordfish off the coast of Florida. This was primarily a small boat, one-night trip type of operation. In a report of the Swordfish Workshop held in Miami in 1977 and summarized by Beardsley (1977), fleet size of the Cuban American fishery was estimated at about 35 boats concentrated mainly between Miami and Key West. Techniques used by the Cuban Americans were adopted by Florida fishermen, with the result that a local fishery for swordfish began to spring up in this area. By 1978, at least 100 vessels were estimated by Florida officials to be involved in the local fishery. Following reports of successful fishing by Miami fishermen, swordfishing activity began along the western Florida coast.* A very rapid increase occurred between 1978 and 1980. The principal fishing ports were Madeira Beach, Ft. Myers, and Panama City. In 1979, shrimp vessels along the Texas coast began entering the swordfish fishery. Most of these vessels have since returned to shrimp fishing. The number of swordfish vessels based in Gulf ports as of 1981 is unknown, but is believed to be between 50 and 100. Most of these are based along the central western coast of Florida.

With the expansion of the fishery to new geographic areas, landings from the South Atlantic region have assumed increasing importance. The percentage of landings by region before 1976 and in 1978 are shown in Figure 8-7.

*Information on the Gulf fishery is provided by C. Davis (Fishery Biologist, Gulf of Mexico Fishery Management Council; pers. comm.).

Table 8-5. Comparison of catch-per-unit of effort and dressed weight of Canadian swordfish landed in 1970 and 1975. (Source: Caddy 1976.)

	Catch/100 Hooks				Average Weight (lbs)			
Unit Area	1970	No. of Fish	1975	No. of Fish	1970	No. of Fish	1975	No. of Fish
4165	-	-	1.35	16	-	-	100.7	16
4166	-	-	1.61	56	-	-	90.1	50
4261	-	-	1.50	9	-	-	100.9	9
4262	0.83	140	2.55	68	88.5	140	111.0	43
4263	0.95	23	1.27	57	98.1	23	88.1	13
4264	1.12	300	0.47	3	82.9	300	-	-
4265	1.06	92	3.33	163	92.6	92	107.0	161
4361	0.69	29	1.25	53	114.8	29	155.3	25
Totals and weighted averages	1.01	584	2.31	425	87.9	584	107.4	317

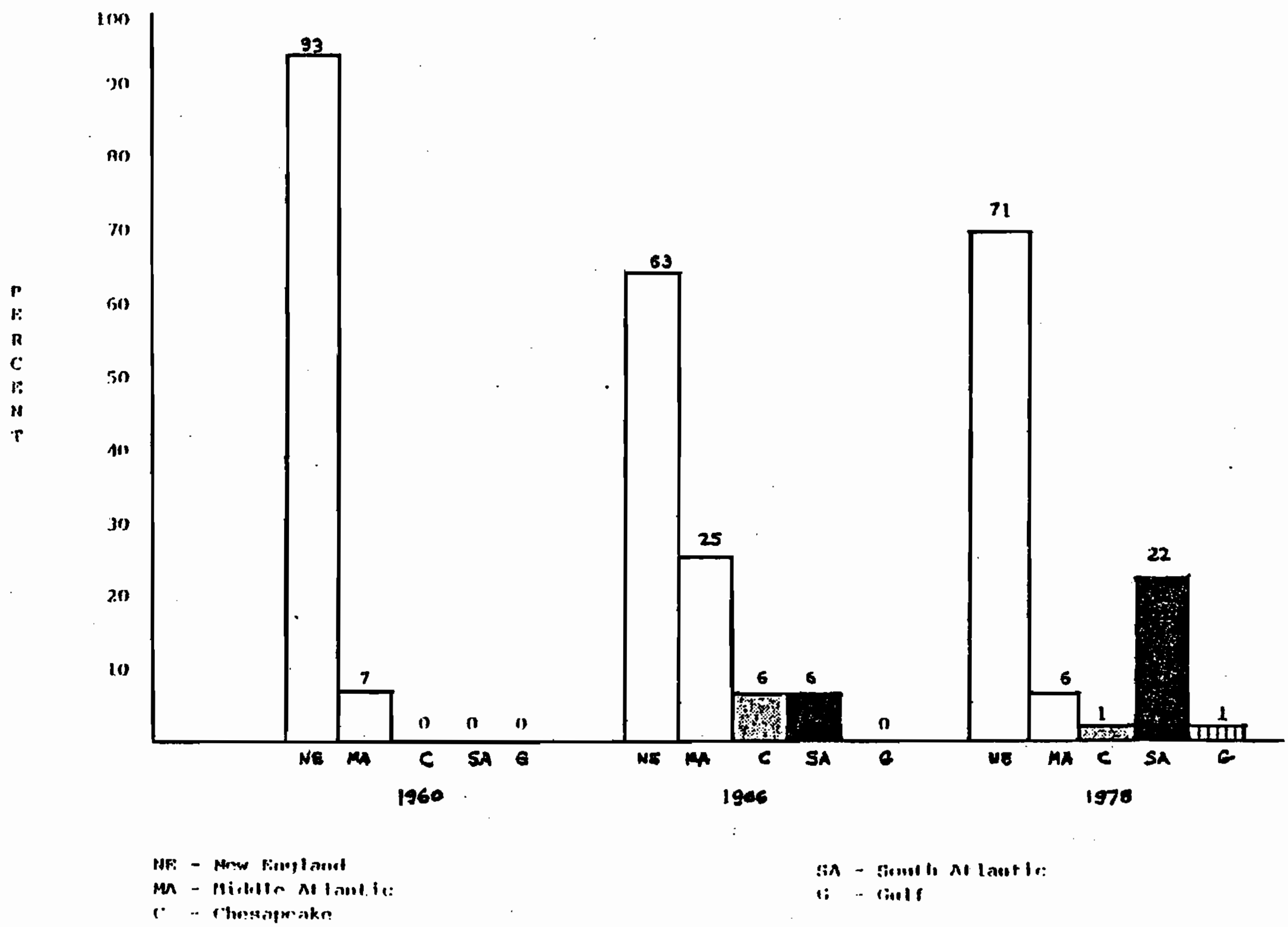


Figure 8-7. Percentage of landings by region, 1960, 1966 and 1978 (Booz et al., 1980).

8.1.5.2 <u>Swordfish Fishery After 1978 (Mercury Restriction of 1.0 PPM)</u>

The FDA 0.5 ppm action level was challenged in 1978 (Anderson Seafood vs. Joseph Califano, Secretary, HEW). Partially based on a more detailed analysis of seafood consumption patterns developed by NMFS (Model for the estimation of the consumption of contaminants from aquatic foods, MFCCA model) the action level was raised to 1.0 ppm. The most recent version of this technique is the Consumer Risk Simulation Model (NOAA Technical Memorandum NMFS-SEFC-18). It is likely that this form of consumer risk modelling will be the technical basis for future court challenges to increase or decrease the FDA action level. (See: Officer and Ryther 1981; Cordle, 1981, for recent discussions on mercury in swordfish.)

Recent data from southern Florida (Berkeley and Houde, 1980) provide a comparison among kinds of swordfishermen and show some trends in the fishery (Table 8-6). Initially recreational tournament fishermen had the highest catch per 100 hooks (10.86) but by 1980 their catch rate (3.14) had fallen below that of Florida longlines (3.38). The lowest mean catch per 100 hooks (1.10) was for the New England longlines.

The mean weight (dressed) of landed swordfish (Table 8-6) ranged from 39.6 to 40.9 kg (87.2 - 90.2 lb) since 1978 for Florida longlines. Initially, recreationally caught fish weighed more but recent catches seem to be similar in weight to the longline catches (Berkeley and Houde, 1980).

The longline fishery for swordfish in the Northwest Atlantic has grown rapidly in recent years. Despite this considerable increase in effort, mean size and size composition of the catch from the Straits of Florida have remained constant. Dressed weight-frequency distributions for 1979 and 1980 are almost identical (Figure 8-2, p. 8-8). The ratio of increase in catches between 1980 and 1979 was 1.44. Mean weights were 44.2 kg (97.4 lb) in 1979 (N = 7985) and 44.1 kg (97.2 lb) in 1980 (N = 14,837). Total reported landings increased from 632.3 mt in 1979 to 910.9 mt in 1980, an increase of 44 percent. Although these figures are known to considerably underestimate actual landings, they may be a valid indication of relative change.

Catch-per-unit effort was calculated by month for 1979 and 1980 (Tables 8-7). CPUE is expressed both as numbers and dressed weight per 100 hooks. Mean CPUE was calculated as the average of ratios CPUE

Table 8-6. Catch and effort of three kinds of swordfish fishermen in southeast Florida. (Source: Berkeley and Houde, 1980)

Boat Type	Dates	Number of Sets	Mean Number of Hooks per Set	Mean Number of Fish per Set	Mean Weight of Fish per Set (dressed) (lbs)**	Mean Weight of Fish (dressed) lbs)**	Mean Catch per 100 Hooks
New England	Jan-Jul 1975-78	141	571	6.28	414.0	73.0	1.10
Florida	Mar-Apr 1978	11	320	6.64	578.7	87.2	2.07
Florida	Feb-Dec 1979	920	219	6.80	675.6	90.2	3.10
Florida	Jan-Mar 1980	109	209	7.05	719.4	87.6	3.38
Recreational	Apr-Sep 1977-78	626*	3.5	0.38	-	127.3	10.86
Recreational	Jun-Jul 1979	121*	3.5	0.14	-	83.0	4.01
Recreational	Jun 1980	73*	3.5	0.11	-	115.0	3.14

* Represents boat-trips.
** Dressed weight = whole weight x 0.75.

Table 8-7. Mean catch per 100 hooks and mean weight by month for swordfish caught in the south Florida longline fishery, 1979 and 1980.

Year/Month	Number of boat trips sampled	Number of fish per 100 hooks	Dressed Weight of fish per 100 hooks* (kg)	Mean Dressed weight* (kg)
1979				
February	11	2.92	116.2	40.2
March	41	3.88	147.6	39.5
April	55	4.98	209.8	42.1
May	112	4.19	219.6	52.7
June	109	4.52	236.0	51.5
July	81	3.95	183.3	44.8
August	90	4.20	166.2	39.0
September	35	3.35	131.8	40.7
October	74	4.35	157.1	35.5
November	46	4.63	204.5	40.1
December	44	4.50	191.4	41.9
Mean 1979	699	4.26	190.5	44.2
1980				
January	49	2.52	104.2	36.1
February	55	2.93	138.2	43.3
March	71	3.05	141.4	49.4
April	62	3.55	158.2	47.2
May	83	3.47	170.4	48.6
June	104	3.37	182.6	49.1
July	49	2.95	147.0	47.1
August	62	2.79	121.7	41.8
September	41	2.40	87.5	37.2
October	32	2.46	87.6	35.8
November	13	2.80	108.6	37.4
December	13	2.52	106.7	38.8
Mean 1980	634	3.03	141.4	44.1

*Dressed weight = whole weight x 0.75

statistic (Rothschild and Yong, 1970). CPUE declined in 1980 in all months except February, April, October and November. The yearly mean catch in numbers per 100 hooks in 1980 was 28.9 percent less than in 1979. The decline by weight was 25.8 percent. Assuming the increase in reported landings is proportional to the increase in actual landings then effort in 1980 increased approximately 94 percent over 1979.

The presence of swordfish in the Caribbean Fishery Management Council area has been known from the Japanese longline incidental catch and the occasional landing of swordfish in the recreational rod and reel fishery and in the commercial fishery. However, the landing of swordfish is such a rare event that they are grouped in the "other fish" category. Weiler and Suarez-Caabro (1980) present an overview of Puerto Rico's small-scale fisheries statistics 1972-1978 and do not report any swordfish landings.

In 1980, the Department of Marine Sciences of the University of Puerto Rico conducted an exploratory swordfish project supported by Sea Grant, Dr. Douglas Y. Shapiro, Project Leader.* A converted Thompson trawler was outfitted with 3.2 km (2 mi) of longline and fished near the edge of the shelf 3.2-4.8 km (2-3 mi) offshore in a depth of 27.4-54.9 m (90-180 ft). A total of 18 trips was made between April 21, 1980 and January 17, 1981 with 1,096 hooks fished. An average of 59 hooks was fished per trip and the CPUE was 0.0055 fish per hook. A total of 6 swordfish was caught, with a mean weight of 30.75 kg (67.8 lb) and an average overall length of 2.2 m (7.22 ft).

Since this exploratory work, two local fishing boats made several trips with longline gear and caught four or five swordfish (exact weights and measurements are not available but one was much larger than those caught in the exploratory fishing.)

In addition, Capt. Luis Mendoza is presently attempting to develop a fishery for swordfish in the Mayaguez area. Fishing from a 45 foot steel

*The information on the exploratory fishing was originally provided by Dr. Shapiro to Mr. Miguel A. Rolon, the Puerto Rican Government representative to the CFMC. Mr. Rolon, in turn, supplied the information to the CFMC and the Council, in a letter from Mr. Omar Munoz-Roure dated April 2, 1981, kindly authorized that it be made available for use in this profile document.

vessel, equipped with a hydraulic longline reel he has experimented with a line similar to the Japanese tuna longline. Cyalume lights are too expensive and there is a problem with fish breaking the lines. However, the major problem is lack of a market; the local price is only $.80 per lb, much below the mainland price.

According to Dr. Shapiro, "Swordfish are in Puerto Rican waters in sufficient numbers to make additional efforts to discover the best fishing sites, depths, and type of gear warranted. I feel that the low yield for our efforts was due to not knowing precisely where and how best to fish. The fact that several local fishing boats have obtained longline gear and have begun their own exploratory trips is a good indication that this exploratory swordfish project was successful at demonstrating the existence of swordfish in local waters and that they can be caught."

8.1.5.3 Drift Gill Net Fishery

Recently a new gear has been introduced in the Northwest Atlantic swordfish fishery. Drift gill net gear presently in use is patterned after the thresher shark gill net fishery in California. The following accounts are condensed from conversations with Ron Tegland (owner of two boats fishing in the northwest Atlantic), Jim Squires (NMFS, California; billfish and swordfish research) and Dennis Bedford (California Fish and Game; Project Leader, Drift Gill Net Study).

Two boats, 21.3 m (70 ft) in length fished drift gill net gear for swordfish during 1980. The net was 47.5 cm (18 in) stretch mesh, 23.8 m (78 ft) deep, 0.81 to 1.01 km (1/2 to 5/8 mi) in length and fished on a longline/net combo drum. The net was fished approximately 5.5 m (18 ft) below the surface and remained attached to the boat at one end. Radar reflectors allowed the crew to monitor the net and if the current started to tangle the gear, one end was let go and the other end pulled tight to prevent entanglement. One net broke free and monitoring on the radar showed that within one hour the net had become an entangled ball of net, rendering it unable to fish.

The net is set at dusk and pulled at approximately 1:00 a.m. The time required to haul the gear varies from 30 minutes, if empty, to 1-1/2 to 2 hours if fish are present. No chemical lights are used in conjunction with the nets. These vessels harpoon during the day and gill net at night.

Twenty sets were made during 1980 in the vicinity of Georges Bank and the only billfish caught were swordfish. It is important to note that other billfish are scarce in this area. The average catch was 2.5 swordfish per set with a mean weight of 129.7 kg (286 lb). In comparison, the mean weight of swordfish harpooned during the day was 117.0 kg (258 lb). The incidental catch in this drift gill net did not include any billfish other than swordfish and did not include any small fish. A pilot whale became caught in the net but was quickly released.

The following discussion of the west coast drift gill net fishery is taken from the Draft Fishery Management Plan for Pacific Coast Billfish and Oceanic Shark Fisheries (Pacific Fishery Management Council; September, 1981).

> A number of gill net fisheries (e.g., gill net, trammel net; inshore, offshore; drift, set) operate off southern California. Of these, the offshore drift gill net fishery is directed at oceanic sharks and swordfish.
>
> Mako shark is caught from Monterey to San Diego generally less than ten miles from shore. Common thresher is caught from Monterey to San Diego. The few blue shark marketed are caught in southern California waters. There is no high seas fishery for oceanic sharks off the coast of California, yet from limited exploratory fishing a high catch rate can be obtained for blue sharks. The drift gill net fishery for thesher shark is expanding. Larger mesh nets are increasingly used to reduce the take of less valuable blue sharks.
>
> Historically, both gill net fisheries have taken incidental catches of swordfish. During 1977 and 1978, it was found that drift gill nets set primarily for thresher shark would take swordfish. Fishing operations were modified where possible to take, along with the thresher, mako, and blue shark, the relatively more valuable swordfish. The fisheries occasionally take incidental numbers of a variety of fishes and some marine mammals.
>
> The gill net fishery landed 1,261 swordfish (150 mt) in 1979, an estimated 30-40 percent of total California landings of this species.
>
> Fishing log data for six drift gill net vessels operating 468 nights in 1979 suggest that the catch of swordfish in this fishery is incidental (approximately 7 percent of the catch of all species) (Table 8-8). There is an even smaller incidental catch of striped marlin.

Table 8-8. Composition of the annual catch of six drift gill net vessels in California in 1979.

Species	Catch		Percent by	
	Numbers	Weight (lbs)	Numbers	Weight* (lbs)
Blue Shark	4,507	202,815	42.0	18.0
Thresher shark	4,556	820,000	43.0	73.0
Mako shark	920	16,560	9.0	1.0
Soupfin shark	176	3,520	2.0	0.3
Swordfish	413	82,500	4.0	7.0
Striped Marlin	18	2,556	0.2	0.2

*Catch (weight) = catch (numbers) x average weight

Observer data through August 1981, tend to confirm the incidental nature of billfish in annual catches of this fishery (Table 8-9).

In 1979, the California Fish and Game Commission authorized the sale of swordfish taken incidentally in the drift gill net fishery. In 1980, legislation authorized the use of gill nets to take sharks and swordfish. The legislation specified entry criteria, mesh size and catch limits. To qualify for a drift gill net permit an applicant must provide evidence (landing receipt) of prior participation in the fishery (1978 or 1979) or provide evidence of serious intent to engage in the fishery (significant investment prior to May 20, 1980). The gill net catch of swordfish is limited to 25 percent of the catch by the harpoon fishery; the catch of striped marlin to 10 percent of that by the recreation rod and reel fishery.

In 1979, an estimated 20-40 drift gill net vessels fished for shark and swordfish. In 1980, 165 boats were licensed for the fishery and 105 boats reported actually fishing. Of the 165 boats having licenses, 94 were registered as dual gear, harpoon and drift gill net.

Several features make the drift gill net an attractive gear to catch swordfish. The gear is set at dusk and retrieved at dawn and is physically non-conflicting with commercial harpoon and recreational rod and reel fisheries. Gill net gear is fuel efficient gear. Fishermen report that the night gill net operation requires about 70 percent less fuel than the day harpoon operation. If both night gill net and day harpoon are fished, the fuel saving approximates 50 percent compared to day harpoon fishing only. Finally, comparison of catches by harpoon and drift gill net gear in 1979 and 1981 indicate that the gear may be more efficient at producing swordfish than is the harpoon fishery, especially during seasons of poor surface availability.

Additional evidence of the efficiency of gill net gear is provided by its extensive use in the Western Pacific to catch swordfish, striped marlin and several species of tuna. Since 1972, drift gill net gear has been rapidly replacing harpoon gear in the Japanese billfish fisheries.

Table 8-9. Observed composition of the catches of 12 drift gill net vessels during 88 nights (1981 season through August). (Source: PFMC, 1981)

Species	Catch (Numbers)	Percent (Numbers)
Blue Shark	281	21.0
Thresher shark	580	43.0
Mako shark	278	21.0
Soupfin shark	14	1.0
Swordfish	5	.3
Striped marlin	0	-
Sea lions	43	3.0
Other (17)	147	10.7

In California, the Legislature can delegate authority to manage specific fisheries to the Commission and this was the case with swordfish. When drift gill nets were initially introduced in California the Commission prohibited their use; however, in September 1980 the Legislature reviewed the situation and lifted the restriction on landing swordfish caught by drift gill nets with two restrictions: the swordfish landed from drift gill nets cannot exceed 25 percent of the cumulative catch of harpoon caught swordfish and the incidental catch of striped marlin cannot exceed 10 percent of the striped marlin caught by the recreational rod and reel fishery.

The drift gill net fishery in California targets thresher sharks and has a very valuable incidental catch of swordfish. Other species caught include blue sharks, makos and a very few striped marlin. Nets are 20.3-40.6 cm (8-16 in) and more recently up to 50.8 cm (20 in) stretch mesh, 1.61 km (1 mi) in length, and 20.1 m (66 ft) deep. They are fished 2.7-3.7 m (9-12 ft) below the surface and flotation is maintained with approximately 100 buoys. The boats involved harpoon during the day and drift gill net from dusk to dawn. Prior to September 15, 1980, the harpoon permit was free and there were 979 permits. After September 15, the cost of a permit was $150, which reduced the number of permits to 408. Of the 408 harpoon permits, 94 were issued to boats with gill net permits. The total number of gill net permits is 165, which includes the 94 dual (harpoon/gill net) boats. Approximately 15 percent of the boats land 90 percent of the catch; the remainder have permits for tax and recreational fishing benefits.

West coast workers conclude that the drift gill net gear is no more efficient than harpoon gear but that the gill net gear extends the fishing season for approximately 2 months longer than the harpoon season because while fish are not "finning" at the surface they are in the area. The gill net gear also increases the effective fishing season of a boat by allowing it to fish at night. Fish caught average 90.7 kg (200 lb) and sell for approximately $3 per pound. While the numbers of fish caught by the drift gill net gear are not large, the value is very important, making up, in many cases, 50 percent of a vessel's gross income.

The California Fish and Game has a program with 12 observers in an attempt to study the drift gill net gear. Based on 76 observer days, only 1 marlin was observed as an incidental catch. Observers report that fish are both gilled and tangled in the nets.

West Coast researchers indicated that there was no danger to the billfish stocks (including swordfish) from the drift gill net gear; the situation is viewed as purely competition between different gear user groups with no biological basis for concern.

8.1.5.4 Recreational Catch and Effort

Results of recreational angling effort, 1977-1980, in the Florida Straits is summarized in Table 8-10. There has been a rather steady decline in the number of fish caught per boat per night from 0.44 in June 1977 to 0.11 in June 1980. Members of the Stuart Sailfish Club fished 11 boat nights during 1981 and caught 4 swordfish (0.36 per boat) with an average weight of 56.02 kg (123.5 lb) (B. Pelosi, South Atlantic Council Advisory Panel Chairman; pers. comm.).

8.1.5.5 Commercial Catch and Effort

Summarized data from the logs of a New England longliner from sets made in the Gulf of Mexico, Florida Straits, and New England area are included as Appendix B. The mean weight (pounds dressed weight) and percent in each size category for the years 1974-78 in the GMFMC, SAFMC and NEFMC areas are given in Table 8-11. It can be seen that the mean weight is lowest in the Gulf of Mexico (28.12 kg; 62.0 lb), increases to between 31.53 and 33.11 kg (69.5 - 73.0 lb) in the Mid and South Atlantic, and is highest in New England (39.46 kg; 87.0 lb) and the Florida Straits (40.37 kg; 89.0 lb). CPUE and weight by area were also calculated from the data in Appendix B (Table 8-12). CPUE (mean catch per 100 hooks) decreased from 1.73 in 1974 to 1.13 in 1976, then increased to 1.98 in 1978. The most recent data available are from Florida (Berkeley and Houde, 1980) and indicate a catch rate of 3.39 in 1979 and 3.55 for the first three months of 1980.

The seasonal peak in effort by southeast Florida longliners occurs in spring-summer (Table 8-13). The highest catch rates were observed during April and October through December 1979, and February and March 1980. Larger fish were caught during May through July 1979, when a greater

Table 8-10. Results of recreational angling for swordfish, 1977-1980, in the Florida Straits. (Source: Berkeley, 1979; Berkeley and Houde, 1980)

Source	Date	Number of Fish	Boat Nights	Number of Fish/Boat/Night	Total Weight (lbs)	Mean Whole Weight (lbs)
Miami Tournament	June 1977	60	135	0.44	11,268.0	187.8
Stuart Sailfish Club	Apr-Sep 1977	74	164	0.45	7,207.5*	171.6
Duck Key Tournament	May 1978	8	15	0.53	1,123.0	140.4
Ft. Lauderdale Tournament	June 1978	30	64	0.47	4,765.0	158.8
Miami Tournament	June 1978	48	172	0.28	7,243.0	150.9
Stuart Sailfish** Club	Apri-Sep 1978	21	78	0.27	4,849.5	230.9
Duck Key Tournament	May 1979	1	12	0.08	294.0	294.0
Ft. Lauderdale Tournament	June 1979	4	33	0.12	405.0	101.3
Miami Tournament	July 1979	13	88	0.15	1,476.0	113.6
Ft. Lauderdale Tournament	June 1980	8	73	0.11	1,227.0	153.4
TOTALS		267	834	0.32	39,858	169.6

*Only 42 fish weighed.
**Records from Stuart Sailfish Club

Table 8-11. Mean weight (pounds dressed weight) and percent in each size category for the years 1974-1978 in the Gulf of Mexico, Florida Straits and New England areas. (From Appendix B.)

AREA	MEAN WEIGHT	PERCENT IN EACH SIZE CATEGORY* %LG	%MED	%SM	%VSM
G.Mex	62.0	19.4	32.1	24.7	23.8
Fla.EastCoast	73.0	23.1	37.9	28.6	10.4
M-A	69.5	17.5	34.9	37.0	10.5
NorthEast	87.0	31.4	42.6	19.6	6.5

* LG over 100 lb. dressed weight
MED 50-99 lb dressed weight
SM 25-49 lb dressed weight
VSM under 25 lb dressed weight

Table 8-12. Catch-per-unit effort (CPUE) and weight by area for the years 1974-1978 in the Gulf of Mexico, Florida Straits and New England areas. (From Appendix B)

		CPUE				WEIGHT					
AREA	YEAR	$\bar{X}$	S_x	$S_{\bar{x}}$	n	$\bar{X}$	n	%LG	%MED	%SM	%VSM
Gulf of Mexico	1974	.0237	.0002	.0140	4	59.1	381	18.1	31.2	24.2	26.5
	1975	.0082	.0000	.0030	4	64.2	141	19.2	31.2	27.0	22.7
	1976	.0058	.0000	.0006	2	78.1	47	21.3	55.3	19.2	4.3
	1977	.0078	.0000	.0050	2	59.9	53	20.8	22.6	30.2	26.4
	1978	.0074	-	-	1	82.0	22	36.4	27.3	18.2	18.2
Fla.EastCoast	1974	-			0		-				
	1975	.0188	.0000	.0033	2	67.2	152	17.8	44.1	25.7	10.5
	1976	.0099	.0000	.0047	5	55.5	283	11.3	38.9	28.3	12.7
	1977	.0111	.0000	.0028	8	74.0	369	29.0	29.0	26.0	7.6
	1978	.0071	.0000	.0030	4	63.4	81	23.5	23.5	17.3	3.7
Mid-Atlantic	1974	.0029	-	-	1	-	8	-	-	-	-
	1975	.0163	.0002	.0149	2	50.5	94	6.4	30.9	35.1	21.3
	1976	.0135	.0002	.0124	3	59.3	131	15.3	22.1	39.7	12.2
	1977	.0492	.0004	.0187	5	69.1	378	18.0	36.0	36.0	8.7
	1978	.0140	.0001	.0103	2	88.7	78	26.9	44.9	28.2	0
Northeast	1974	.0182	.0001	.0068	10	81.1	53	81.1	18.9	0	0
	1975	.0157	.0001	.0107	8	87.6	371	33.2	40.7	17.5	8.6
	1976	.0139	.0001	.0095	7	73.5	332	23.2	36.2	34.6	6.0
	1977	.0271	.0002	.0149	2	70.8	150	14.7	61.3	20.7	3.3
	1978	.0345	.0006	.0238	9	91.3	570	34.7	44.7	13.7	6.8

Table 8-13. Catch-per-unit effort and mean weights by month for swordfish caught by south Florida longliners, 1979 and 1980. (Source: Berkeley and Houde, 1980).

Year and Month	Number of Boat Trips	Number of Fish per 100 Hooks	Dressed Weight of Fish per 100 Hooks (lbs)**	Mean Dressed Weight (lbs)**
1979				
February	11	2.69	245.6	90.1
March	40	3.77	313.6	86.9
April	55	4.75	436.1	92.5
May	148	3.08	358.3	116.0
June	181	2.70	309.6	113.3
July	132	2.35	240.4	98.5
August	131	2.89	247.4	85.5
September	36	3.04	262.3	89.5
October	76	3.95	313.8	78.2
November	54	4.08	390.6	87.5
December	56	3.97	372.8	92.7
1980				
January	48	2.69	260.5	80.0
February	52*	4.00	433.0	92.9
March	9	3.97	342.2	89.7

*Incomplete data.
**Dressed weight = whole weight x 0.75.

number of large females were caught (Berkeley and Houde, 1980). Preliminary aerial overflights estimated approximately 0.11 boats per nautical mile (based on 15 flights, each covering between 72 and 127 miles of coastline) (Berkeley, 1981).

In the Gulf, the principal fishing areas are around the mouth of the Mississippi river and west northwest of Key West, Florida (C. Davis, Fishery Biologist, GMFMC; pers. comm.). The best fishing occurs in late winter and early spring, a few months earlier than along the southeast coast.

8.1.5.6 Abundance and Present Condition

Beardsley (1977) reports that the general trend of the Japanese data "leads to the conclusion that the abundance of swordfish stocks in the entire Atlantic, in general, has not been significantly reduced and is still capable of supporting some increase in fishing effort." Trends in CPUE in the North Atlantic from Japanese tuna longline data from 1957 through 1976 are presented in Figure 8-8. CPUE in the North Atlantic during this time has fluctuated in the range of 2.0 to 7.0 fish per 10,000 hooks (0.02 to 0.07 fish per 100 hooks) with an overall upward trend. Any conclusions derived from the Japanese longline fishery "must be interpreted with considerable caution" (Wise and Davis, 1973), because Japanese longline efforts have been historically directed primarily toward tuna, with activities occurring for the most part during the daytime although setting and hauling of the line extends into nighttime hours. Yearly increases in CPUE may also reflect the increasing expansion of longline vessels into geographic regions in which swordfish have previously been unexploited.

Some evidence of stock reduction (marked decrease in average size and CPUE was reported for the Canadian longline fishery in the northwest Atlantic during the 1960's at an effort level of around six to seven million hooks (Beckett, 1975; Caddy, 1976). However, part of the decrease in size was attributed to the catch of swordfish in warmer offshore waters where small swordfish comprise a large proportion of the catch.

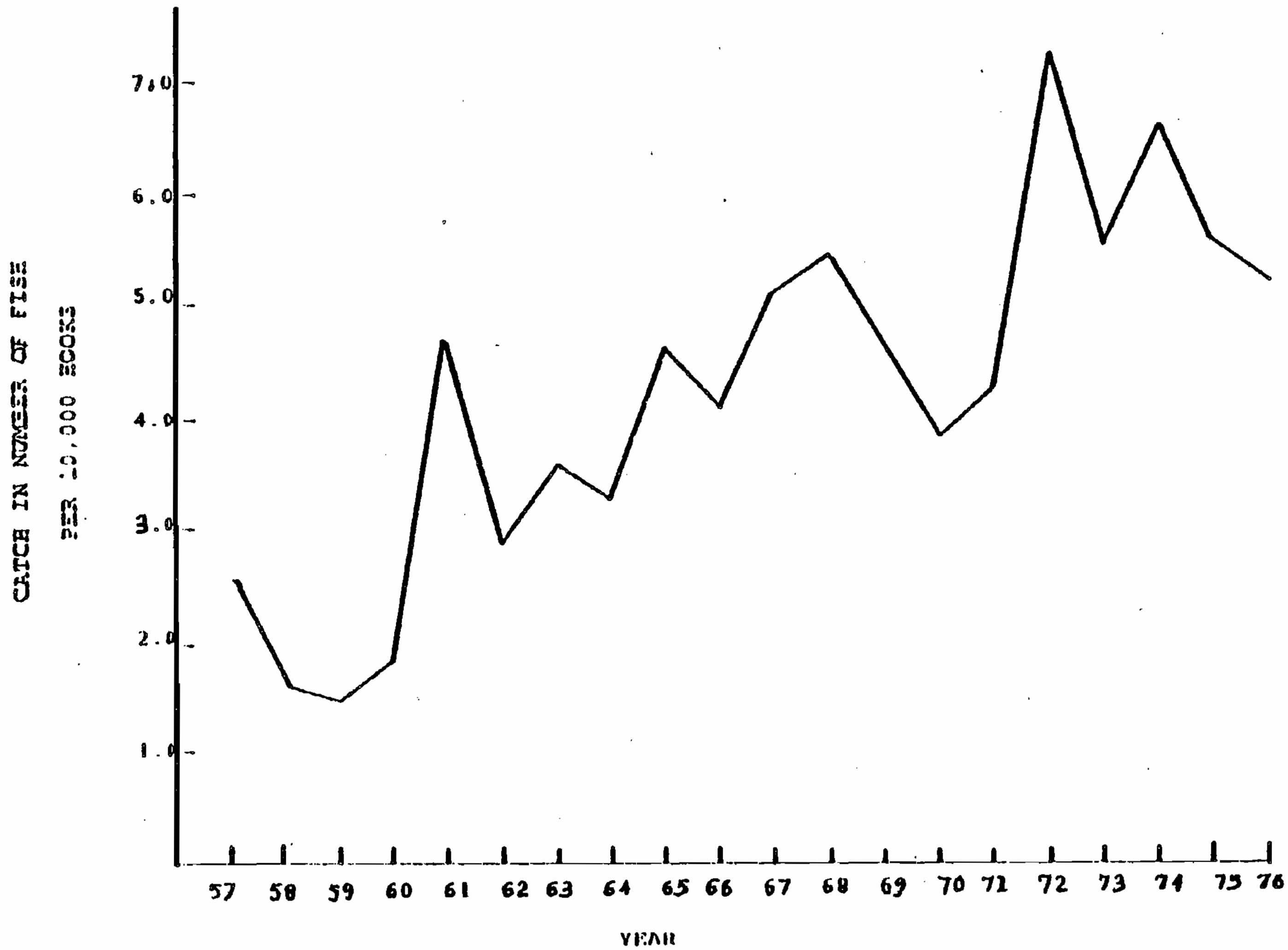


Figure 8-8. Catch-per-unit of effort in the North Atlantic Ocean 1957-1976. (Source: Japanese Longline Data.)

Historical landings and value data presented in Table 8-14 illustrate the fluctuations in swordfish landings over the period 1960-76. There were lower landings in 1961-62 and 1968-73, and higher landings in the years 1960, 1963-67 and 1974-76. A portion of the decrease in the 1968-73 time frame was due to poor reporting associated with the mercury restrictions. More recently reported landings have increased even further to a peak of 7.5 million lb in 1980 (Table 8-15).

Preliminary information from South Carolina (E. Joseph, Director, South Carolina Marine Resources Center, Charleston, S.C.; pers. comm.) documents a decreasing average size for swordfish landed in South Carolina: (1) 1978 mean dressed weight = 40.92 kg (90.2 lb); (2) 1979 mean dressed weight = 37.01 kg (81.6 lb); and (3) 1980 mean dressed weight = 33.75 kg (74.4 lb). Mean dressed weights from south Florida (Berkeley and Houde, 1980, 1981) during the same time period were as follows: (1) 1978 = 39.46 kg (87.0 lb); (2) 1979 = 44.2 kg (97.9 lb); and (3) 1980 = 44.1 kg (97.2 lb). The South Carolina data indicate a decline from 1978 to 1979 and 1980 and the Florida data indicate no significant change from 1979 to 1980. However, both data sets have a smooth distribution when weight is plotted against frequency. This indicates that the age structure contains significant numbers of older, mature fish and does not imply any recruitment problem to date.

8.1.6 Probable Future Condition

Yield-per-recruit (YPR) analysis (Berkeley and Houde, 1981) indicates that, for females, fishing effort is at the level that would maximize yield-per-recruit; however for males, present effort is well below the maximum level. Any additional increase in fishing effort would result in growth overfishing of the female portion of the stock. In addition, it is not known to what extent recruitment may be influenced by reducing spawning potential.

8.1.7 Interdependence on Other Species

8.1.7.1 Incidental Species

Sharks, tunas and other billfish species are caught incidentally in the domestic directed longline swordfish fishery. The problems associated with tunas and other billfish are discussed in Section 8.4.6. Sharks are presently

Table 8-14. Historical swordfish landings and value data by Council area (Source: Appendix A)

YEAR	NEFMC '000 lb	NEFMC '000 $	MAFMC '000 lb	MAFMC '000 $	SAFMC '000 lb	SAFMC '000 $	GMFMC '000 lb	GMFMC '000 $	TOTAL ALL AREAS '000 lb	TOTAL ALL AREAS '000 $
1960	942	380	69	37	-	-	-	-	1,011	417
1961	829	320	72	34	-	-	-	-	901	354
1962	867	377	67	38	-	-	-	-	934	415
1963	2,331	577	423	186	1	1	-	-	2,755	764
1964	1,456	431	1,113	379	483	233	-	-	3,052	1,043
1965	788	305	1,391	580	524	283	-	-	2,703	1,168
1966	855	346	425	196	77	38	-	-	1,357	580
1967	641	250	404	159	-	-	-	-	1,045	409
1968	389	193	216	106	-	-	-	-	605	299
1969	336	163	40	18	-	-	2	1	378	182
1970	268	163	18	10	-	-	346	249	632	422
1971	73	71	4	2	-	-	1	(1)	78	73
1972	541	756	-	-	-	-	-	-	541	756
1973	873	1,249	7	10	-	-	14	14	894	1,273
1974	3,353	3,280	76	107	-	-	86	149	3,515	3,536
1975	4,294	5,315	149	262	-	-	149	256	4,592	5,833
1976	3,408	4,604	187	302	262	355	391	816	4,248	6,077

Table 8-15. Recent landings (round weight) and value data for the swordfish fishery. (Source: Preliminary Data - NMFS).

	NEW ENGLAND & MID-ATLANTIC FMC AREAS (ME,NH,MA,RI,CT,NY,NJ)		(DE,MD,VA)		SOUTH ATLANTIC FMC AREAS[2] NC		SC		FL.E.COAST		GULF OF MEXICO FMC AREAS[3] FL.W.COAST		TX[4]		TOTALS	
	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$
1977	1,272,343	N/A[1]	6,018	9,663	120,000	210,000	0	0	113,000	172,000	2,321	2,308	0	0	1,513,682	2,442,443
1978	5,512,971	7,192,149	47,768	72,206	439,306	668,688	581,542	817,573	536,000	941,000	52,708	93,907	0	0	7,172,917	9,790,767
1979	4,683,412	7,256,837	N/A		170,436	253,585	822,711	1,009,341	1,391,000	2,893,000	318,000	579,000	60,000	N/A[5]	7,445,559	12,100,963
1980	2,751,524	4,918,704	N/A		316,576	455,243	845,097	1,154,746	2,004,000	3,004,000	630,000	1,624,000	966,000	N/A[6]	7,513,197	13,648,973

1. 1.61
2. GA landed 2,622 lb worth $5,244 in 1978.
3. AL, MS and LA reported no landings.
4. During 1979 landings were by out-of-state boats, landing in Galveston. The initial success stimulated the development of a fishery by state boats landing at Aransas Pass in 1980. All landings are shipped out-of-state and the price per lb follows Florida's price.
5. 1.82
6. 2.58

covered under the Preliminary Management Plan (PMP) of January 1978 for Sharks and Billfish. However, a PMP applies only to foreign fishermen and as such would not impose any restrictions on the domestic swordfish fishery. When a shark FMP is prepared, management measures could potentially impose restrictions on the swordfish industry.

Table B-4 in Appendix B shows the number and percent of total billfishes caught incidental to swordfish for the years 1974 to 1978 for one domestic longline vessel. Total billfish caught for this 5 year period were: sailfish -13, white marlin - 42, and blue marlin - 3. During the same period 3,837 swordfish were caught.

8.1.7.2 Marine Mammal/Endangered Species Interactions

Marine mammals and sea turtles are caught very infrequently in the longline fishery. Catches from observer data indicate that in the Japanese tuna longline fishery 12 turtles and no marine mammals were caught in 199 sets (451,902 hooks) during 1979 in the Gulf of Mexico (Table 8-16). The percent mortality ranged from 10-50 percent. During 1979, in the Atlantic in 295 sets (663,551 hooks) 17 turtles and 5 marine mammals were caught (Table 8-17). The percent mortality for turtles was 37.5 percent and for marine mammals it ranged from 0 percent for porpoise up to 50 percent for one of the two false killer whales.

The incidental turtle catch by Council area is given in Table 8-18. During 1979, the catch ranged from a high of 12 in the GMFMC area to 2 in the SAFMC area. There were no incidental catches reported for the NEFMC area. In 1980, catches varied from 9 in the MAFMC area to 1 in the SAFMC area.

The recent introduction of drift gill net gear into the NEFMC area may impact turtles and marine mammals. Section 8.1.5.3 discusses this fishery and Tables 8-8 and 8-9 contain information on the incidental catch in drift gill net gear.

8.1.8 Estimate of MSY

MSY cannot be estimated from a surplus production model because accurate catch and effort data are not available for the swordfish fishery. The Japanese CPUE data have some serious drawbacks: (1) the fishery targets tuna, not swordfish; (2) the tuna fishery is primarily a daytime fishery; and (3) tuna fishing strategy minimizes the incidental catch of billfish and swordfish.

Table 8-16. Observed catches of sea turtles and marine mammals in the Gulf of Mexico for 1979 from observer data. (Source: Thompson, in press)

Species	No. Caught	Mean Catch/100 Hooks	Standard Deviation	95% Confidence Limits Lower	Upper	Mortality(%)
Turtle Unidentified	10	0.0022	0.0105	0.0007	0.0036	10.0
Leatherback	2	0.0004	0.0043	-0.0002	0.0010	50.0
Loggerhead	0	-	-	-	-	-
Porpoise Unidentified	0	-	-	-	-	-
Bottlenose	0	-	-	-	-	-
False Killer Whale	0	-	-	-	-	-
No. of Sets	199.0					
No. Hooks	451902.0					

Table 8-17. Observed catches of sea turtles and marine mammals in the Atlantic for 1979 from observer data. (Source: Thompson, in press)

Species	No. Caught	Mean Catch/100 Hooks	Standard Deviation	95% Confidence Limits Lower	95% Confidence Limits Upper	Mortality(%)
Turtle Unidentified	8	0.0011	0.0069	0.0004	0.0019	37.5
Leatherback	0	-	-	-	-	-
Loggerhead	9	0.0013	0.0089	0.0003	0.0023	00.0
Porpoise Unidentified	2	0.0004	0.0044	-0.0001	0.0009	00.0
Bottlenose	1	0.0001	0.0021	-0.0001	0.0004	00.0
False Killer Whale	2	0.0003	0.0055	-0.0003	0.0010	50.0
No. of Sets	295.0					
No. Hooks	663551.0					

Table 8-18. Turtle incidental catch in the Japanese tuna fishery as reported by observers. (Source: S. Drummond, Chief, Branch of Fishing Survey, Pascagoula Lab., SEFC)

	1979				1980			
MONTH	GMFMC	SAFMC	MAFMC	NEFMC	GMFMC	SAFMC	MAFMC	NEFMC
Jan			1					
Feb	5				7			
Mar	4				1			
Apr	3						3	
May								
Jun								
Jul								
Aug			1					
Sep		1					3	
Oct		1				1	3	
Nov			7					
Dec								
TOTALS	12	2	9		8	1	9	

In contrast, estimates of growth and mortality for swordfish were recently published. These estimates were used to calculate yield-per-recruit (YPR). The published data are from Florida but for management purposes the stock covers the entire western North Atlantic and the Florida estimates are expected to be representative of the stock.

8.1.8.1 Yield-per-Recruit Analysis *

Based on the best point estimates of the growth and mortality parameters, a yield-per-recruit (YPR) analysis was carried out using the Beverton and Holt (1966) yield tables. Separate analyses were done for males and females because of their widely divergent parameter estimates.

The estimated mean length at entry into the Florida longline fishery (L_c) is 119 cm (46.9 in) fork length, which corresponds to the estimated mean length at age II when whole weight is approximately 20 kg (9.1 lb). This L_c was used for both males and females as there is no apparent difference in length at recruitment by sex. Figure 8-9 gives the relationship between yield-per-recruit (in kg) and fishing mortality rate (F) for males and females using the following parameters:

Males	Females
L_{oo} = 217.4 cm	L_{oo} = 340.0 cm
K = 0.1948	K = 0.0946
M = 0.27	M = 0.14
M/K = 1.37	M/K = 1.50
C = 0.55	C = 0.35

where $C = L_c/L_{oo}$

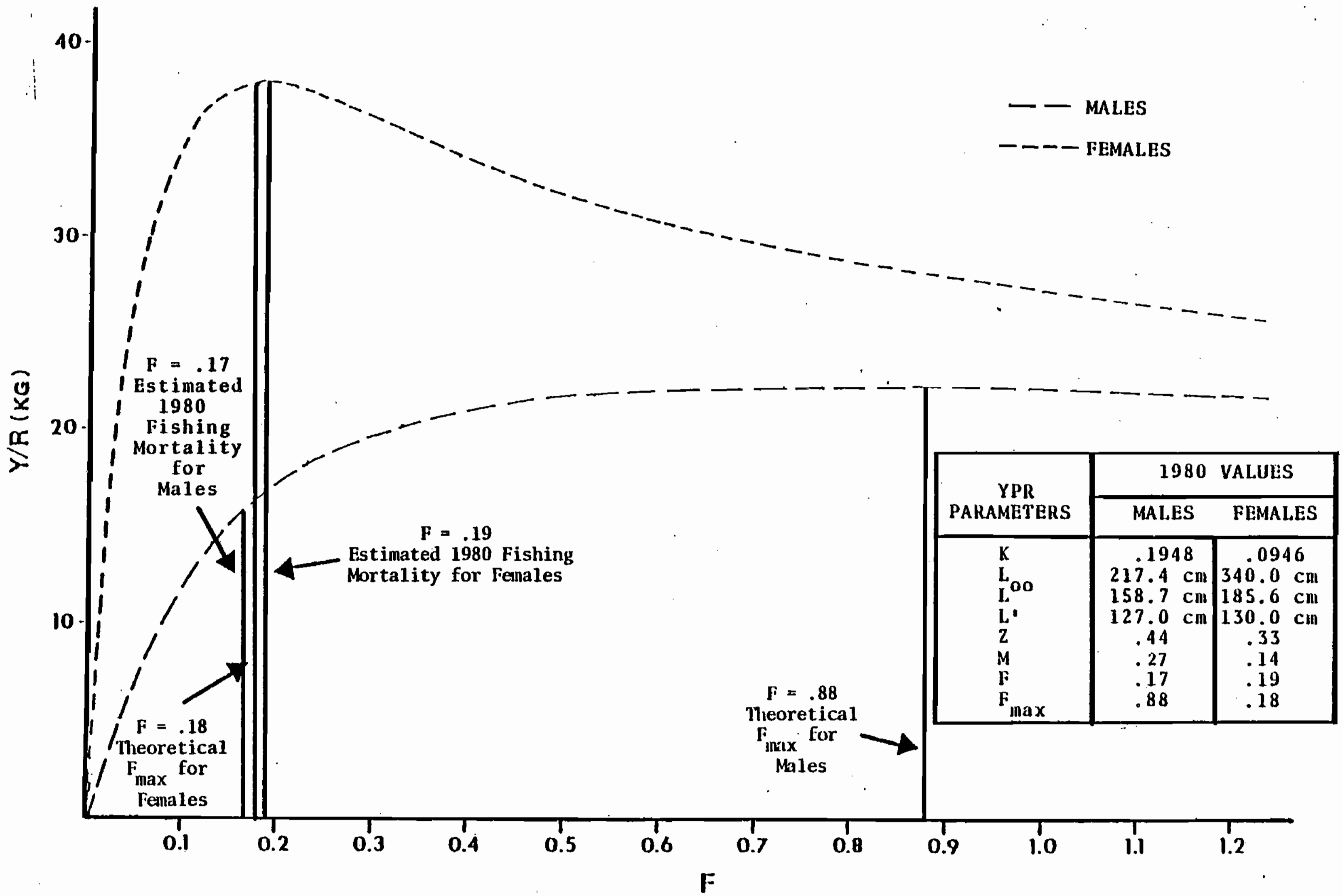
Assuming that the best estimates of Z are those given by the maximum likelihood method then estimates of the present levels of fishing mortality are:

Males	Females
F = 0.17	F = 0.19

Under present circumstances the fishing mortality coefficients that would maximize yield-per-recruit (F_{max}) are:

Males	Females
F_{max} = 0.88	F_{max} = 0.18

* Taken from Berkeley and Houde (1981).



YPR PARAMETERS	1980 VALUES MALES	1980 VALUES FEMALES
K	.1948	.0946
L_{oo}	217.4 cm	340.0 cm
L	158.7 cm	185.6 cm
L'	127.0 cm	130.0 cm
Z	.44	.33
M	.27	.14
F	.17	.19
F_{max}	.88	.18

Figure 8-9. Yield curves for Florida swordfish. Yield-per-recruit (YPR) is given in relation to the fishing mortality coefficient (F) for males and females. (Source: Modified from Berkeley and Houde, 1981).

These results indicate that female swordfish are presently being fished at F_{max} while the exploitation rate for males is well below F_{max}. An increase in YPR of 6.0 kg (13.2 lb) might be realized by increasing effort on males to F = 0.88.

8.2 Description of Habitat

8.2.1 Condition of Habitat*

The hydrographic habitat of swordfish in or near U.S. management jurisdiction is the Gulf Stream system, including the Loop and Florida currents and waters inshore, and the Caribbean Sea in the vicinity of Puerto Rico and the Virgin Islands. The western "edge," "wall" or "front" of the Gulf Stream is characterized by having a greater temperature contrast to the slope water than the eastern front has, and the temperature contrast is used by fishermen to determine the edge. The western front is also often identified by a color boundary, a current change, as well as by long thick lines of Sargassum weed or other flotsam on the surface.

The Gulf Stream from Florida to Cape Hatteras is often coincident to the 600 foot (approximately 200 meter) isobath (or bottom curve). The position of the Gulf Stream varies in wavelike patterns, which are known as meanders. The amplitudes of the meanders are greater north of Cape Hatteras than south of Cape Hatteras to the Tortugas. This is particularly important because, in the process of meandering, the Gulf Stream may be outside the FCZ.

The circulation in the eastern Gulf of Mexico (east of the Mississippi River) is dominated by the Loop Current, which enters the Gulf through the Yucatan Straits and exits through the Straits of Florida. The path of the Loop Current varies considerably with time and although the Loop Current does not directly flow over the continental shelf, eddies that detach from the current, similar to Gulf Stream eddies, drift on to the shelf carrying warm, saline Caribbean waters.

The Caribbean Sea is connected to the Atlantic by Mona Passage to the west of Puerto Rico and Anegada Passage to the east of the Virgin Islands. Surface currents in the vicinity of Puerto Rico and the Virgin Islands include the Caribbean and Antilles Currents which result from the convergence of the North Equatorial Current with the Guiana Current. The Caribbean Current flows through the Caribbean Sea while the Antilles Current flows to the north of the islands.

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*Booz et al., 1980

Based on food habits in the northwest Atlantic and in south Florida, swordfish appear to spend at least a part of their time on or near the bottom feeding on organisms which live just off the bottom.

8.2.2 Habitat Areas of Particular Concern

The swordfish is a pelagic species which is widely distributed in oceanic and coastal waters. However, it is also found near the bottom along the continental shelf, and thus apparently must utilize this region as a habitat.

Swordfish spawning grounds (Section 8.1.2.1) are evidently at or near the surface of oceanic waters, relatively far from coastal sources of pollution. However, offshore oil spills and the possible impact of tar and tar balls in the open ocean (Horn et al., 1970; Burns and Teal, 1973) may be deleterious to the young stages because components of tar which may be carcinogenic (Kraybill et al., 1977) can enter into the food chain of pelagic ecosystems (Evans and Rice, 1974). No quantitative data are available on the relationship between the distribution of swordfish larvae and oceanic pollutants, such as tar and tar balls.

Adults living at the surface can be expected to be affected by oil spills and tar balls for the reasons stated above. Those living in subsurface waters could receive pollutants, such as heavy metals, pesticides and radionuclides, via the food chain which cycles from neritic waters to the epipelagic and to the mesopelagic, which is the important, deep-water habitat of oceanic swordfish (Chipman, 1966; Walsh, 1972; Harvey, 1974; Windom and Duce, 1977).

Swordfish living on or near canyons of the continental shelf could be affected by pollutants carried through direct ocean dumping, as is common in the FCZ (Kullenberg, 1975) or through transfer from the neritic zone to the bottom waters overlying the continental shelf. Pollutants thus could be taken up directly by swordfish or more likely, through their food which had acquired them from surface or neritic waters (Leatherland et al., 1973). Squid, for example, have rather high concentrations of heavy metals (Martin and Flegal, 1975) but the degree to which this results from man-made pollutants as compared to natural sources, and how these affect swordfish is unknown. Thus, while the swordfish is an offshore, pelagic fish, man-made activities may affect it or its habitat.

8.3 Fishery Management Jurisdiction, Laws and Policies

8.3.1 Management Institutions

The U.S. Department of Commerce, acting through the five eastern regional councils—New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, and Caribbean—pursuant to the Magnuson Fishery Conservation and Management Act (MFCMA) (P.L. 94-265), has authority to manage swordfish stocks throughout the U.S. Fishery Conservation Zone (FCZ) in the Northwest Atlantic, the Gulf of Mexico, and the Caribbean Sea.

8.3.2 Treaties and International Agreements

Foreign fishing for swordfish in U.S. waters is regulated solely through the Magnuson Act. The United States is a member of the International Commission for the Conservation of Atlantic Tunas (ICCAT). Because swordfish are caught by foreign participants in the Atlantic tuna longline fishery, statistics on the catch are maintained by this commission; however, no plans currently exist to manage or regulate the swordfish fishery through international commissions. The U.S. longline fishery catches tunas as an incidental catch (S. Berkeley, Research Associate, University of Miami, Miami, FL; pers. comm.).

The Canadian government barred U.S. fishermen from the Canadian fisheries zone in June 1978 and the United States took similar action against Canadian fishermen shortly thereafter. By de facto agreement the two nations have maintained flag state enforcement within the region claimed by both: The U.S. exercises jurisdiction over U.S. ships and Canada has jurisdiction over ships flying the Canadian flag, each state reserving the right of enforcement against any third state.

8.3.3 Federal Laws, Regulations and Agreements

The only federal law that relates to the management of the Atlantic, Gulf and Caribbean swordfish fisheries is MFCMA. Until a Fishery Management Plan for this species is approved by the Secretary of Commerce, this fishery will be managed through the Preliminary Fishery Management Plan (CFR 50§ 611.60), prepared by the Department of Commerce (U.S. Department of Commerce, 1978). Briefly stated, these regulations require that foreign longline fishermen release billfishes (of which swordfish are included) and maintain catch records.

In December 1970, the swordfish fishery went into a decline, as a result of the FDA mercury restriction of 0.5 ppm. The enforcement of the 0.5 ppm mercury level amounted to a ban on swordfish. Importation from Canada dropped below 50,000 pounds per year, and domestic commercial harvesting continued at a reduced rate.

On June 27, 1978, essentially as a response to the ruling of the U.S. District Court for the North District of Florida in two cases (Anderson Seafoods vs. FDA and FDA vs. Anderson Seafoods), the FDA issued an administrative guideline (FDA, 1978) instructing its inspectors to take enforcement action only against fish with mercury levels in the edible parts exceeding 1.0 ppm. The decision of the Florida court was appealed by those seeking to have the acceptable level of mercury in swordfish raised. The decision on the appeal was not to alter the level from 1.0 ppm. The American Swordfish Association, relying on the toxicological findings of the Florida court and on new consumption evidence prepared by the National Marine Fisheries Service, attacked the 1.0 ppm action level for mercury and asserted that only an action level of 4.0 ppm is required (Anon, 1979a). However, the FDA is maintaining the 1.0 ppm action level. In denying petitions of the National Food Processors Association and AMR Biological Research, FDA stated that the agency had reviewed the new data on fish consumption and determined that the action level of 1.0 ppm is appropriate to regulate unavoidable residues of mercury in fish (Anon, 1979b).

Not all swordfish meet the 1.0 ppm limit for mercury. The difficulty for the fishermen and processors is not only in meeting the limit, but in the loss involved if fish is impounded for testing, which takes five to six days. Imports must meet the lower of either the U.S. standard or the standard in the country of origin.

8.3.4 State Laws, Regulations and Policies

Massachusetts limits the catch of sport swordfish by noncommercial fishermen to one fish per angler per day. Although Massachusetts does not require a license for recreational fishing, the commonwealth prefers that boats landing fish in the commonwealth have a Massachusetts boat license.

Only two states, Delaware and Florida, have laws regulating the utilization or taking of billfishes, which are taken as an incidental catch in the U.S. longline fishery. The text of these regulations follow.

Delaware - Statute § 1310

Illegal Possession of Atlantic sailfish, blue marlin, white marlin and striped marlin; penalties

"(a) No person shall sell, possess for sale, offer for sale, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport or cause to be transported, carry or cause to be carried, by any means whatever, for the purpose of sale, or barter, the carcass, processed byproduct, or any portion thereof of any Atlantic sailfish (Istiophorus americanus), blue marlin (Makaira nigricans ampla), white marlin (Makaira albida) or striped marlin (Makaira mitsukurii).

(b) This section shall not apply to Atlantic sailfish, blue marlin, white marlin or striped marlin, whole, packed or processed in transportation in unbroken packages and coming from any other state or country, but such packages shall be clearly marked by stencil, tag, or otherwise, showing the true origin of the shipment and its destination beyond the limits of this State.

(c) Any person who violates any provision of this section shall be fined not more than $1,000 for each offense, or be imprisoned for not more than 30 days for each offense.

(d) The Superior Court shall have jurisdiction of offenses under this section."

Florida - Statute 370.11

Regulation; Fish; Sailfish; Penalty

"5. No person may sell, offer for sale, barter, exchange for merchandise, transport for sale, either within or without the state, offer to purchase or purchase any species of fish known as sailfish; provided, however, any one person may carry out of the state as personal baggage or transport within or out of the state not more than two sailfish if they are not being transported for sale. The possession of more than two sailfish by any one person is unlawful; provided, however, any person may catch an unlimited number of sailfish if they are immediately returned uninjured to the water and released where the same are caught. No common carrier in the state shall knowingly receive for transportation or transport, within or without the state, from any one person for shipment more than two sailfish except as hereinafter provided. It is expressly provided that any lawful established taxidermist in the conduct of taxidermy, may be permitted to move or transport any reasonable number of sailfish at any time and in any manner he may desire, as specimens for mounting; provided, however, satisfactory individual ownership of the fish so moved or transported can be established by such taxidermist at any time upon demand. Common carriers shall accept for shipment sailfish from a taxidermist when statement of individual ownershp involved accompanies bill of lading or other papers controlling the shipment.

6. SAILFISH TRANSPORTING - Sailfish being transported shall be kept intact and flesh shall not be removed from the skeleton; provided, however, sailfish after having been delivered to a bona fide taxidermist or smoking establishment, may be dismembered."

8.3.5 Local and Other Applicable Laws, Regulations and Policies

No local or other laws, regulations or policies are known to exist relative to the swordfish fishery.

8.4 Description of Fishery Activity

8.4.1 History of Exploitation

8.4.1.1 Recreational

A sport fishery for swordfish has existed since around the 1920's. Rich (1947) notes that "in former times", i.e., prior to around 1930, small-boat men caught swordfish off Martha's Vineyard and Nantucket by "trailing" a hook baited with some silvery fish such as herring. Few swordfish were taken with rod and reel. Moss (1967) estimated that in an average season only about 50 swordfish would be caught by rod and reel in about 1,000 attempts, in the area stretching from Massachusetts to Long Island. The main technique used was to locate a fish which was on the surface and then attempt to entice it to strike a nearby bait (Wilcoxson, 1975). This method was seldom successful. Harpooning of swordfish has also been practiced occasionally by sport fishermen.

The U.S. recreational swordfish fishery has grown considerably during the 1970s. Since 1976, a substantial rod and reel fishery for swordfish has grown up in Florida. In the new methods developed in Florida, fishing is done at night and the bait is drifted below the surface utilizing techniques copied from the Cubans. These new techniques have proven to be much more successful than traditional daytime trolling techniques for swordfish and have been key factors in opening up new sport fisheries for swordfish in areas where none previously existed. Consequently, the number of participants in the recreational sector of this fishery has increased significantly in recent years.

8.4.1.2 Commercial

Longline gear was introduced to Canadians by Norwegian shark fishermen who caught substantial numbers of swordfish as an incidental catch (Mr. R. Bartlett, Advisory Panel member; pers. comm.). Further, after the first summer season, the Norwegians hung up their gear and a winter fishery for swordfish was developed by Canadian fishermen.

An accurate, concise overview of the swordfish fishery is given by Berkeley and Houde (1980):

> "Swordfish have been fished commercially in the northwest Atlantic since the 19th century. Until 1962 virtually all swordfish

were harpooned and fishing was confined to waters between New York and Canada during summer. In 1960 the estimated total catch of swordfish in the northwest Atlantic was 2800 metric tons (Caddy, 1976). In the early 1960's longline gear was introduced into the fishery, mostly by Canadian fishermen. In 1963 the estimated total catch had increased to 8800 m.t. It declined the next year and stabilized at about 5000 m.t. until 1971. With the introduction of longlining the range of the fishery expanded. By the middle 1960's it extended from Canada to the Gulf of Mexico and operated year round. In 1971, as a result of United States Food and Drug Administration guidelines that prohibited sale of swordfish with more than 0.5 ppm tissue mercury content, the swordfish fishery collapsed (Caddy, 1976). Some Canadian and United States boats continued fishing clandestinely although total effort was greatly reduced. Reported total catches from the western North Atlantic (Zones 21 and 31) declined to 800 m.t. in 1971 (FAO, 1976). In 1978, the permissible level of mercury was raised to 1.0 ppm. This resulted in rejuvenation of both the Canadian and the United States fisheries. FAO (1979) reported 7077 metric tons landed from the western North Atlantic (Zones 21 and 31) in 1978. The catches almost certainly have increased in 1979 and 1980, but good landings data are not presently available. The reported catch from Florida in 1979 was at least 777 m.t., which is probably a gross underestimate of actual landings."

The first cooperative longline catch of swordfish was made in the Gulf of Mexico in 1969, and the first commercial catch in 1970 (M. R. Bartlett, Advisory Panel Member; pers. comm.).

8.4.2 Domestic Recreational and Commercial Fishery Activities

8.4.2.1 Participating User Groups

The problem of clear definition between recreational and commercial fishing activities in the swordfish fishery is a major one since:

> Most fish caught are too large for consumption by an individual sport fisherman; thus, many recreational fishermen resort to selling the product.

The value of swordfish is high, making it highly lucrative to sell the catch.

The costs involved in sports fishing for swordfish are high; thus, many sports fishermen regard the sale of the catch as a method for defraying these costs.

8.4.2.1.1 Recreational

Prior to 1976, very few swordfish were caught by rod and reel. Wilcoxson (1975) reported that in all probability less than 2,000 swordfish had been caught in the history of sport fishing.

Swordfish have been sought by marine anglers from Nantucket, Massachusetts, to Shinnecock, Long Island, during summer months ever since 1926, when the first swordfish was caught by rod and reel in this part of the Atlantic (Freeman and Walford, 1974). Swordfish were also occasionally, but infrequently taken by billfish anglers in the Middle Atlantic Bight (de Sylva, 1974). Annual tournaments have been held in New York, Massachusetts, and Rhode Island for a number of years. Prior to 1976, the usual method of angling for swordfish was to attempt to entice a basking swordfish to strike at a baited hook placed within 30 feet of its mouth (Freeman and Walford, 1974; Wilcoxson, 1975). This was rarely successful, since swordfish do not customarily feed while at the surface.

In 1976, rod and reel fishermen in south Florida began to experiment with night fishing techniques adopted from Cuban American longliners. These efforts were more successful than previous methods. In a report of the Swordfish Workshop held in Miami in 1977, summarized by Beardsley (1977), it was estimated that in 1976 approximately 25 to 30 swordfish were landed by rod and reel in Florida; in 1977 landings were expected to exceed 400 to 500 fish. The sport fishery for swordfish using the new techniques has rapidly expanded along the Atlantic Coast from south Florida to Cape Cod and to the Gulf of Mexico (International Marine Angler, 1978). Swordfish tournaments were initiated in Florida in 1977. In 1978, swordfish tournaments were held in South Carolina and New Jersey, the first ever to be held in these states (International Marine Angler, 1978).

Berkeley and Houde (1980) reported a decrease in recreational effort in Florida during 1978 and 1979 and expect a further decrease in tournament effort in 1980. Their reasons include loss of interest on the part of anglers and relatively poor success in 1979 tournament fishing.

8.4.2.1.2 Commercial

There are three types of commercial effort directed at swordfish in southern Florida (Berkeley and Houde, 1980): 1) a mobile New England fleet of vessels larger than 50 ft which fishes the Florida Straits primarily in winter and spring, usually north of Ft. Pierce; 2) Florida longline vessels, approximately 35-50 ft long, mostly based in the Miami-Cape Canaveral areas; and 3) Cuban-American type longline vessels, usually 25-40 ft long and which mostly fish between Key West and Miami. A substantial number of the Florida longline vessels are based along the Florida west coast (C. Davis, Fishery Biologist, GMFMC; pers. comm.).

A surface harpoon fishery for swordfish is centered in New England off Montauk, Long Island*. Estimates of the harpoon fleet in New England range from 25 to 28 vessels on an annual basis with approximately 22 airplanes. The harpoon fishery is confined to northern waters and is a seasonal fishery which takes place during the summer months (May through October). Traditionally, the harpoon season is over when the first significant storm occurs in the fall. Because of the seasonal nature of the harpoon fishery, many of the harpooners are active in diversified fisheries such as herring, flounder, squid, lobster and scup at other seasons of the year. The main activity is offshore dragging.

8.4.3 Vessels and Fishing Gear

8.4.3.1 Recreational

Rod and reel fishing for swordfish requires heavy tackle similar to that used for tuna and other large billfish. Rods are rated at 50, 80 and 130 pounds; reels are rated similarly. Leaders, which typically are 15 to 30 feet long, are rated at 150 to 300 pounds, and hooks are the 12/0 to 14/0 size. Fishing line and other ancillary equipment is also heavy duty. Line is typically 50 to 80 pound test.

Vessels used for rod and reel swordfish fishing are similar to those used for tuna and other billfish and have been described by de Sylva (1974). Boats used range from 6.1 to 15.2 m (20 to 50 ft) depending on location. These may be either privately owned or chartered. Such vessels fish by drifting in Florida or, in the northeast, occasionally by trolling after a

*Much of the information on the harpoon fishery is from discussions with Everett Mills and Forrest Hoxsie of the New England Advisory Panel.

swordfish has been seen. Baits are placed deeper than for other billfishes. A typical charter vessel for swordfish angling carries four to six fishermen, plus a captain and a mate (D. de Sylva, Professor, University of Miami, Miami, FL; pers. comm.).

In Florida waters, because of the proximity of the Gulf Stream, smaller boats can be used for swordfishing by rod and reel. Vessels as small as 5.5 m (18 ft) are occasionally reported to be rod and reel fishing in these waters.

8.4.3.2 Commercial

Three principal types of commercial effort are present in the Florida fishery (Table 8-19). The New England longline vessels fish the eastern coast from the New England states to Florida. Fishing effort directed at swordfish would fall within one of the vessel types described in Table 8-19.

Characteristics of longline gear used by the New England type vessel have been described by Rhule (1969). Florida's commercial longline gear and methods have been described by Berkeley et al. (1981) and are shown in Figure 8-10. Construction and operation of longline gear for artisanal fishermen suitable for use in the developing swordfish fishery in the Caribbean area are discussed by Berkeley (in press). Boston mackerel, Western mackerel, squid and mullet are some commonly used baits for longlining. Chemical lights are often attached to the line just above the bait as a means of attracting swordfish to the bait. Sharks and billfishes are caught by swordfish longline gear as an incidental catch.

Harpooning is carried out in the daytime during calm weather when swordfish are found at the surface. Typical harpoon gear is shown in Figure 8-11. Harpoon vessels typically range from 18.3 to 25.9 m (60 to 85 ft) in length although there are a few vessels of 12.2 to 13.7 m (40 to 45 ft) which make day trips only. Vessels designed for harpooning are equipped with spotting towers and crows nests, from which crew members can survey the surrounding waters (Anon, 1978). Most harpooners use spotter planes to locate fish. The following account of the use of airplanes is from Cornell (1981):

Table 8-19. Characteristics of the three principal types of commercial effort presently fishing in Florida waters. (Source: Berkeley and Houde; pers. comm.)

Vessel Type	Boat Length	Miles of Longline	Hooks Fished Per Night	Nights Fished Per Trip	Days at Sea	Area Fished	Number Vessels Fishing in Florida	Disposal of Catch
New England Longline Vessels	60'-80'	15-40 mi	400-2000	7-15	10-21	New England states during summer & fall. Move south as winter approaches. Gulf of Mexico or Florida east coast during winter.	Approximately 25 fished during 1979/80.	Most of the swordfish landed is off-loaded directly into trucks and driven or air freighted to the New York or Boston markets. These fish do not show up in Florida landings because they were not sold through local dealers.
Florida Longline Vessels	35'-50'	5-20 mi	100-400	1-2	2-3	Most are based in the Miami to Cape Canaveral areas and usually depart and return to the same port each trip.	Number increased from approximately 50 in 1978 to perhaps 200 at present. Some of these only fish swordfish during spring and summer, while many fish year round.	Sold through local dealers.
Cuban-American Type Longline Vessels	25'-40'	1-5 mi	75-150	1	1	Mostly between Miami and Key West	These vessels established the Florida swordfish fishery and numbered approximately 30 in 1977. However, there are few if any active in the fishery at the present time. Some gave up swordfishing and others switched to the Florida type gear.	Sold through local dealers.

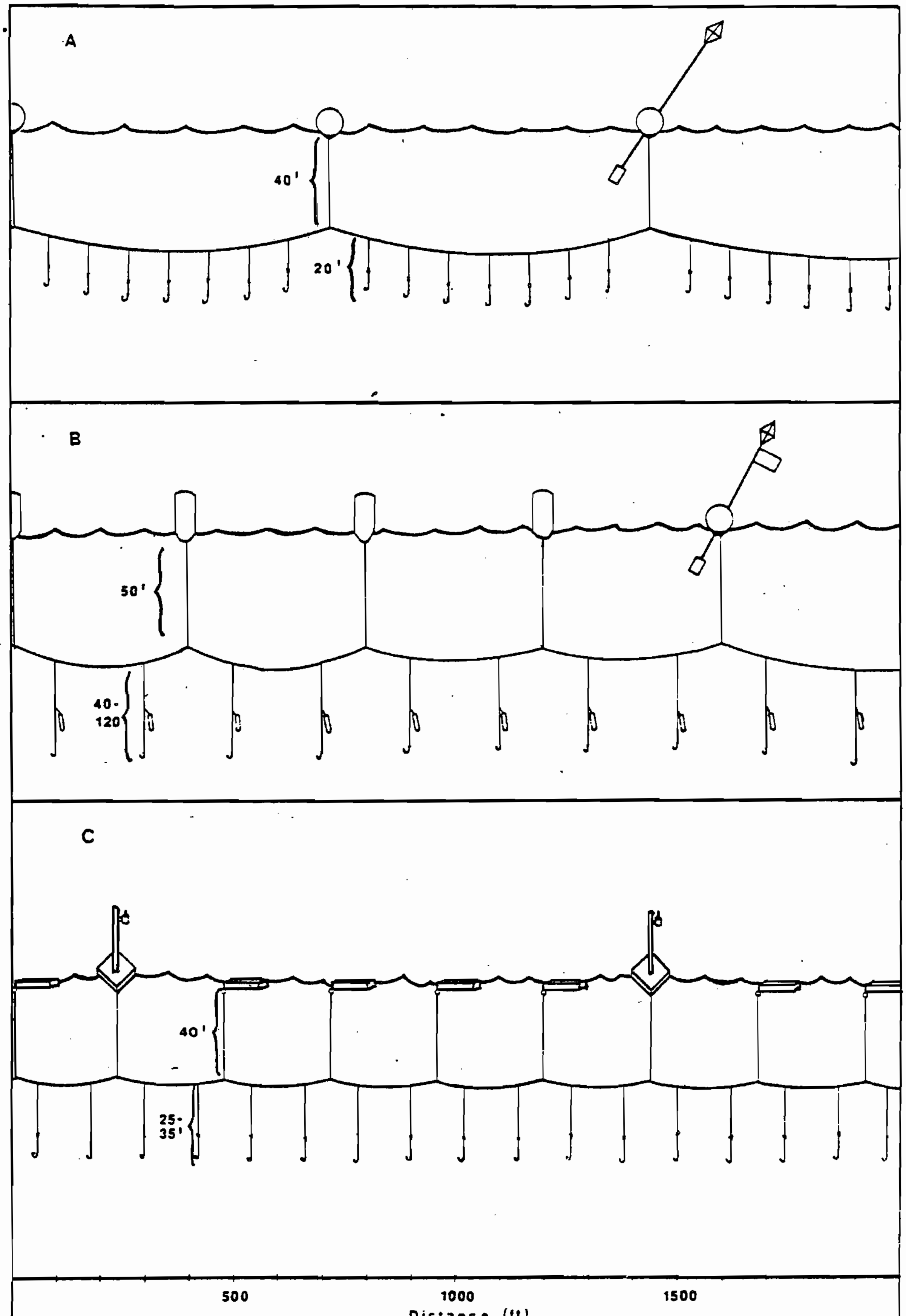

Figure 8-10. A) Typical New England swordfish longline; B) Typical Florida longline; C) Typical Cuban longline. (Source: Berkeley et al., 1981)

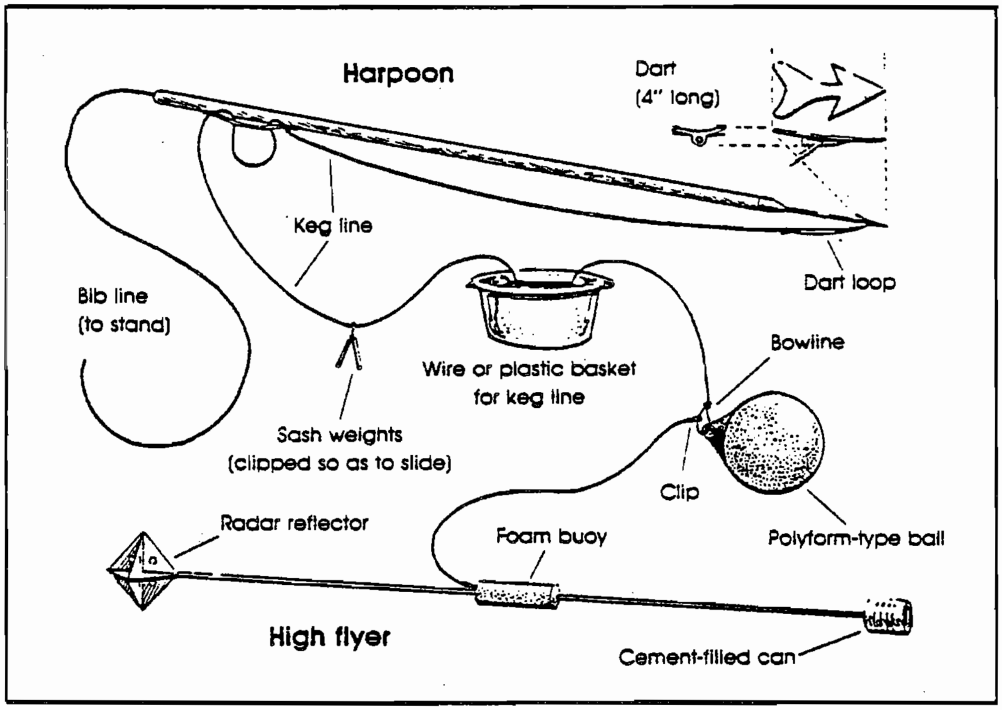

Figure 8-11. Basic harpoon gear used in the Georges Bank swordfish fishery. (Source: Cornell, 1981)

> "The use of aircraft to spot swordfish is an integral - and critical - part of the harpoon fishery on the East Coast. (By contrast, their use is prohibited by state law in the waters of California where the West Coast's swordfish fleet operates). The planes used are invariably either Citabrias or Super Cubs, and all are equipped with extra-large wing tanks and substantial belly tanks, enabling them to stay in the air for some 14 hours.
>
> Guided to their boats by loran bearings given over the VHF (each plane also carried its own loran set), these aircraft fly a random search pattern in the vicinity of the boats, with their altitude varying from about 200' to 800' off the water, depending on the conditions. When the pilot spots a fish, he drops a dye marker near it and banks the plane into a turn, "holding the circle" and "talking" his boat to the fish using the clock system for direction and boat lengths for distance."

The planes fly about 400 hours per year over approximately 35-36 fishing/flying days. Harpooning takes place from an extended bow pulpit using hand-held harpoons. Harpooned fish may be marked with buoys and reflectors and hauled on board after all harpooning within the area is completed.

The harpoon and longline segments of the commercial fishery exploit different weight classes of fish. Swordfish taken by harpoon gear are generally females averaging over 90.7 kg (200 lb). Swordfish taken by longline gear are much smaller on the average, i.e., average weight less than 90.7 kg and range less than 4.5 to over 136.1 kg (10-300 lb), and consist of both males and females.

8.4.4 Foreign Fishing Activities

8.4.4.1 Foreign Fishing Within the FCZ

There is no foreign fishing activity that targets swordfish; however, swordfish are caught as an incidental catch in the foreign longline tuna fishery and the foreign squid trawl fishery.

Historically, only Japanese longliners have fished for tuna within the U.S. FCZ. The resulting billfish incidental catch has been regulated since January of 1978 by a Preliminary Management Plan (PMP). A PMP applies only to foreign fishermen and is prepared by the Secretary of Commerce prior to the development of a fishery management plan by a Fishery Management Council. The PMP for Atlantic Billfishes and Sharks requires that any billfish by-catch be released without being removed from the water.

The total incidental swordfish catch for the Japanese tuna longline fishery for the years 1978 through 1980 is shown in Table 8-20. The estimated observer catch is consistently greater than the Japanese reported catch. This could reflect different fishing strategies. The 1980 incidental swordfish catch by area (Table 8-21) indicates that the Gulf and Mid-Atlantic catches are approximately equal and account for all but 558 swordfish caught in the South Atlantic out of a total catch of 4,911 swordfish.

Swordfish make up approximately 50 percent of the incidental 1980 billfish catch in the Gulf and Mid-Atlantic and only about 10 percent in the South Atlantic (Table 8-22). This trend seems to have occurred for the past three years. Also, note that there is close agreement between the observer extrapolated data and the Japanese reported data on a percentage basis (Table 8-22) but not on a numerical swordfish basis (Table 8-21).

A very important factor in the release of the swordfish incidental catch is the mortality rate. Discounting long term mortality, the initial mortality averaged over the years 1978 through 1980 was 66 percent as reported by the Japanese and 76 percent as estimated from the observer data (Table 8-23). This means that approximately 66-76 percent of the swordfish incidental catch that is released is subjected to initial mortality.

A more detailed analysis of the 1978 foreign fishery in the Gulf of Mexico is given in Table 8-24. The percent swordfish in the catch varied from a high of 12.86 percent in March to a low of 1.96 percent during July 1-17. The CPUE was highest in March, dropped to its lowest level in April and increased steadily through July. The percent mortality is high, ranging from 63-77 percent.

The available monthly observer data for 1979 and 1980 is shown in Table 8-25. During 1979, the catch varied from 185 in the SAFMC area to 377 in the GMFMC area; the total catch for 1979 was 796 swordfish. In 1980, the catch ranged from 172 in the SAFMC area up to 601 in the MAFMC area; the total 1980 catch was 1,362 swordfish, a 71 percent increase over 1979.

Table 8-20. Total incidental swordfish catch (number of fish) extrapolated from observer data and data reported by the Japanese. (Source: NMFS Observer Program Data)

	YEAR		
	1978	1979	1980
Japanese Data	4,992	3,797	4,911
Observer Data	6,626	4,425	8,075

Table 8-21. Longline incidental swordfish catch (number of fish) by area as reported by the Japanese for the years 1978-1980. (Source: NMFS Observer Program Data)

AREA	YEAR 1978	1979	1980
Gulf	770	2,450	2,068
South Atlantic	828	394	558
Mid-Atlantic	3,382	953	2,285
Total	4,992	3,797	4,911

Table 8-22. Percent swordfish in incidental billfish catch by region for the years 1978-1980. (Source: NMFS Observer Program Data)

	Japanese Data			Observer Data		
YEAR	GULF	SATL	MIDATL	GULF	SATL	MIDATL
1978	15.4	16.6	67.8	14.9	16.7	68.4
1979	64.5	10.4	25.1	54.8	11.9	33.3
1980	42.1	11.4	46.5	54.7	6.5	38.8

Table 8-23. Number and percentage of swordfish that are dead when released for the Gulf and Atlantic areas. (Source: NMFS Observer Program Data)

	Japanese Data				Observer Data			
Year	Gulf	%	Atl	%	Gulf	%	Atl	%
1978	512	66.5	2,285	54.3	714	72.3	3,563	63.2
1979	1,624	66.3	874	64.9	1,781	73.4	1,492	74.6
1980	1,355	65.5	1,503	52.9	3,640	82.5	2,319	63.4

Table 8-24. Swordfish incidental catch by month as recorded by U.S. observers aboard Japanese longline vessels in the Gulf of Mexico in 1978.* (Source: Lopez et al., 1979)

	Sets	Hooks	Number Swordfish	% Total Catch	Number Live	Number Dead	Percent Mortality	Number Turtles
March	13	27,162	22	12.86	8	14	64%	
April	18	40,096	13	3.24	3	10	77%	
May	40	77,070	30	4.09	11	19	63%	
June	46	101,600	59	2.42	14	45	76%	2
July 1-17	50	119,550	88	1.96	21	67	76%	4
Total	167	365,478	212	2.57	57	155	73%	6

* The target species from 1 March to 1 June was bluefin tuna; yellowfin tuna was the target species from 1 June to 17 July. These data do not represent the total catch by Japanese longline vessels in the Gulf of Mexico in 1978; they represent observer data based on 21 boardings during which 167 fishing days were monitored.

Table 8-25. Swordfish incidental catch in the Japanese tuna fishery as reported by observers. (Source: S. Drummond, Chief, Branch of Fishing Survey, Pascagoula Lab., SEFC; pers. comm.)

	1979				1980			
MONTH	GMFMC	SAFMC	MAFMC	NEFMC	GMFMC	SAFMC	MAFMC	NEFMC
Jan		74	13		21			
Feb	219				180		35	
Mar	82				370			
Apr	76				18		8	
May								
Jun							8	
Jul			31				52	
Aug		6	9			8	18	
Sep		25	3			3	54	
Oct		29	5			137	198	
Nov		51	160			14	146	
Dec			13			10	82	
TOTALS	377	185	234		589	172	601	
1979 TOTAL	796							
1980 TOTAL					1,362			

The historical swordfish incidental catch from the Caribbean area is shown in Table 8-26. The swordfish catch ranged from a low of 0 during 1958-61 to a high of 367 in 1963. If only the years when swordfish were caught (1962-1977*) are considered, the catch per 100,000 hooks varied from 3 in 1969 to 68 in 1974. The catch in 1974 is important because so few hooks (13,312) were fished. The mean catch per 100,000 hooks for the years 1962-1977 was 16.

The incidental swordfish catch in the foreign squid trawl fishery is shown in Table 8-27. Based on a 20 percent observer coverage, the observed swordfish catch for 1978 was 18.6 MT (41.1 thousand lb). If this figure is expanded to the fleet of 60 vessels engaged in the squid fishery the total 1978 swordfish incidental catch was approximately 93 MT (205.5 thousand lb). In 1979, 62.8 MT (138.4 thousand lb) were caught, and 115.7 MT (255.2 thousand lb) in 1980, an increase of 24.4 percent from 1978.

8.4.4.2 Foreign Swordfish Fishery in the North Atlantic

Nations which reported catches of swordfish from the North Atlantic to FAO in 1979 included Canada, Cuba, Japan, Korea Republic, and Venezuela.

Canada officially reopened its swordfish fishery in 1979 and has set a quota of 3,000 MT (6.6 million lb). The Canadian fishery for swordfish is a mixed gear fishery consisting of longliners and harpooners; fleet size is around 50 to 60 vessels. Characteristics of vessels and gear are similar to the U.S. fishery. Cuba and Spain both have directed longline fisheries for swordfish.

Japan catches swordfish in its daytime, longline, tuna-directed fishery. Japanese vessels are normally larger than American vessels with an average length of 184 feet (49.8 meters) (Southeast Foreign Fishery Observer Project, NMFS). A typical longline is about 40 to 70 miles long with about 2,000 hooks. Setting the longline begins and is usually completed before sunrise. The line is left out for 2 to 3 hours. Hauling the longline takes from 12 to 16 hours. The average time per set is around 20 to 22 hours (Southeast Foreign Fisheries Observer Project, NMFS). Korea and Taiwan also longline for tuna in the Atlantic and catch swordfish as a by-catch. Vessels and gear are similar to the Japanese.

Swordfish are also caught in the squid fishery by vessels utilizing bottom and mid-water trawl gear.

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*There has been no longline fishing effort by the Japanese in this area since 1977.

Table 8-26. Swordfish and other billfish incidental catch from the Japanese longline fishery in areas 4-1565 and 2065 (two 5^{o} squares from 15^{o}N to 25^{o}N and 65^{o}W to 70^{o}W). (Source: T. Chenning, pers. comm.)

YEAR	NUMBER HOOKS[1]	SWORDFISH		WHITE MARLIN		BLUE MARLIN		SAILFISH		BLACK MARLIN	
		C	CPUE[2]	C	CPUE	C	CPUE	C	CPUE	C	CPUE
1958	37,440					64	171				
1959	112,437			1	1	224	199	26	23		
1961	2,806					12	428				
1962	1,830,572	246	13	2,279	124	18,514	1,011	413	23		
1963	1,896,493	367	19	5,985	316	9,267	489	430	23		
1964	2,124,433	220	10	5,155	243	3,167	149	377	18	32	2
1965	1,020,820	59	6	2,242	220	1,873	183	899	88		
1966	1,368,524	205	15	3,466	253	1,418	104	1,011	74	81	6
1967	202,221	13	6	1,365	675	320	158	80	40		
1968	170,205	12	7	1,502	882	243	143	31	18	3	2
1969	91,377	3	3	140	153	163	178	15	16		
1970	567,846	53	9	1,455	256	1,437	253	123	22		
1971	526,473	66	13	905	172	791	150	140	27		
1972	-										
1973	31,680	6	19	42	133	73	230				
1974	13,312	9	68	3	23	15	113	66	496		
1976	10,660	3	28	2	19	2	19				
1977	2,423	1	41								
TOTAL	10,011,562	1,263	16	24,542	245	37,583	375	3,611	36	116	1

1. Number of records = 12,034
2. CPUE = catch-per-unit effort = catch per 100,000 hooks.

Table 8-27. Observed incidental catch of swordfish in the squid trawl fishery during 1978,* based on 20 percent observer coverage. (Source: William Stevenson, NMFS, St. Petersburg, FL.; pers. comm.)

Northwest Atlantic Area	Observer Trips	Swordfish Observations	Total Amount Swordfish** MT	'000 lb
1	20	18	5.2	11.5
2	76	41	7.7	17.0
3	46	16	4.7	10.4
4	56	6	.9	2.0
5	23	2	.1	0.2
TOTAL	221		18.6	41.1

YEAR	Number Swordfish	Total Amount Swordfish+ MT	'000 lb
1979	1,153	62.8	138.4
1980	2,126	115.7	255.2

*In 1978, there were 250 foreign vessels permitted to fish in the Northwest Atlantic; of these, only about 110 actually fished. Of these 110 vessels, about 60 engaged in the squid fishery.

**These totals are for the observed boats. The expanded figure for the fleet of 60 vessels is 93 mt.

+These totals are for the entire fleet.

Stock removals of swordfish from the North Atlantic by country are shown in Figure 8-12 and Table 8-28. Canada fishes for swordfish in the Northwest Atlantic with stock removals from FAO Statistical reporting area 21. Cuba catches swordfish in areas 31 and 34. Spain's fishing areas in the North Atlantic are in FAO area 27. Stock removals by Venezuela occur in FAO areas 31 and 34. Korea reports stock removals from areas 21, 31 and 34. Foreign nations do not currently land swordfish caught outside the FCZ in U.S. ports.

8.4.4.3 Foreign swordfish fishery in the western North Atlantic

Nations which reported catches of swordfish from the western North Atlantic to FAO in 1979 included Canada, Cuba, Japan, Republic of Korea, USA and Venezuela. The total 1979 harvest was 4,371 MT (9.6 million lb) (Table 8-29). The 1979 U.S. harvest accounted for 76 percent of the total western North Atlantic reported landings.

The best available data support a western North Atlantic swordfish stock hypothesis. Given that this is the case, management of the U.S. domestic fleet will have a significant beneficial effect on the swordfish stock. In addition, by reducing the foreign longline and trawl incidental swordfish catches (principally Japan and Spain) management will further benefit the stock.

8.4.4.4 Landings and Value as Distributed Among the Stock Comprising the Management Unit

Landings of swordfish from the western North Atlantic as reported to FAO are presented in Table 8-29. If we assume a 1980 take of approximately 10 million lb (1979 = 4,371 MT = 9,638,492 lb), the major countries and gear involved are as follows.

The 1980 Japanese incidental catch in the FCZ was 4,911 swordfish* (589,320 lb) as reported by the Japanese and 8,075 swordfish (969,000 lb) as extrapolated from observer data. Observer data reported an initial mortality rate of 76 percent, which implies an initial loss of between 3,732 and 6,137 swordfish (447,840-736,440 lb). Using the 1980 ex-vessel price of \$1.91 per lb across all sizes of fish (Table 8-31), the 1980 value was between \$0.9 and \$1.4 million.

The Japanese Fishery Association has recently proposed to turn over dead swordfish resulting from Japanese tuna longlining activities in the FCZ to an American sponsored group. This offer is currently receiving attention in various quarters.

*Average weight = 120 lb

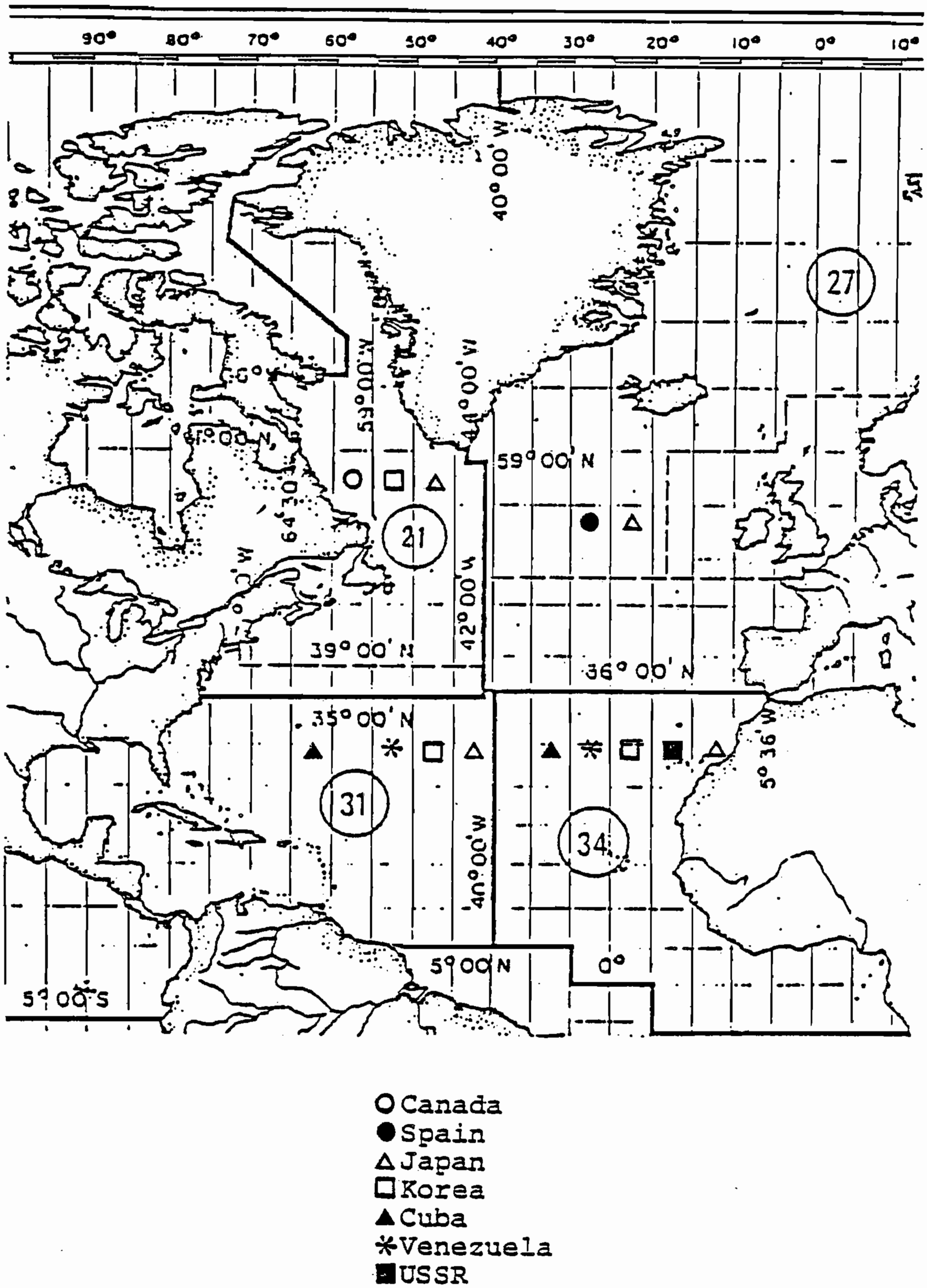

Figure 8-12. Stock removals of swordfish in the North Atlantic. (Source: FAO, Yearbook of Fishery Statistics.)

Table 8-28. Swordfish catches[1] (MT) from the North Atlantic.[2] (Source: FAO, Yearbook of Fishery Statistics.)

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Canada	4,800	a	100	a	2	21	60	117	3,053	50
Cuba	a	a	a	a	a	a	600	700	600	400
Ireland	a	a	a	a	a	3	1	a	a	a
Japan	400	900	900	600	1,170	1,032	717	272	514	574
Korea Republic	a	a	a	a	a	38	a	1	1,000	436
Morocco	200	400	300	200	208	133	199	150	179	208
Norway	400	200	a	a	a	a	a	a	a	a
Poland	a	a	a	100	a	a	a	a	a	a
Spain	2,200	2,200	1,000	7,300	2,178	3,836	2,101	4,531	2,369	999
Togo[3]	a	a	a	a	2	3	200	421	NL	NL
USA	300	a	300	a	1,367	2,019	1,632	910	3,232	3,321
USSR	200	200	200	200	1,400	263	157	87	146	58
Venezuela	-	100	a	a	43	65	43	29	90	90
Ghana[3]									1.998[b]	a
Other	200	300	400	400	400	400	200	264	320	a
Total	8,700	4,300	3,200	8,800	6,770	7,813	5,910	7,482	13,456	6,696

1 FAO statistical reporting areas 21, 27, 31 and 34. (Figure 8-3)
2 Live weight equivalent
3 Togo became Ghana from 1978 onwards.
a None reported
b FAO estimate
NL Not listed

Table 8-29. Swordfish catches[1] (MT) from the western North Atlantic.[2] (Source: FAO, Yearbook of Fishery Statistics)

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Canada	4,800	a	100	a	2	21	15	110	3,053	50
China	0.0[b]	0.1[b]	NL	NL	NL	NL	NL	NL	NL	NL
Cuba	a	a	a	a	a	a	400	400	400	100
Ireland	a	a	a	a	a	3	1	a	a	a
Japan	100	600	300	300	406	290	416	364	269	267
Korea Republic	a	a	a	a	a	38	142	42	11	263
Mexico	a	a	a	a	a	NL	NL	NL	NL	NL
Morocco	a	a	a	a	a	a	a	a	a	a
Norway	a	a	a	a	a	a	a	a	a	a
Poland	a	a	a	100	a	a	a	a	6	a
Spain	a	a	a	a	a	a	a	a	a	a
Togo[3]	a	a	a	a	a	a	a	a	NL	NL
USA	300	a	300	400	1,158	1,924	1,927	910	3,232	3,321
USSR	a	a	a	a	a	a	a	a	a	a
Venezuela	a	100	a	a	43	65	43	29	90	90
Ghana[3]	NL	NL	NL	NL	NL	NL	NL	NL	a	a
Other[b]	a	100	200	200	200	200	150	170	160	280
Total	5,200	800	900	1,000	1,809	2,541	3,094	2,025	7,221	4,371

1 FAO statistical reporting areas 21 and 31. (Figure 8-3)
2 Live weight equivalent
3 Togo became Ghana from 1978 onwards.
a None reported
b FAO estimate
NL Not listed

Estimated catches of swordfish by foreign vessels participating in the squid trawl fishery in the FCZ was approximately 115.7 MT (255.2 thousand lb) for 1980, as extrapolated from observer data. Assuming virtually a 100 percent mortality rate and a value of $1.91 per lb, the 1980 value of this catch was approximately $487,000. This catch occurred in the area from Cape Cod to Cape Hatteras.

8.4.5 Conflicts Between Domestic and Foreign Fishing

There are basically two types of interactions between domestic and foreign fishermen: (1) foreign longline vessels - domestic longline vessels, and (2) foreign longline vessels - domestic recreational rod and reel vessels.

The domestic longline fleet has undergone rapid expansion during the last two years resulting in more direct gear conflict in the Gulf of Mexico and Atlantic waters.

There are numerous areas along the Atlantic and Gulf* coasts of the United States where U.S. sport fishermen come into direct contact with Japanese longliners. Some of these are in the Gulf of Mexico off Port Aransas, Texas and the Mississippi Delta; off Cape Hatteras, North Carolina; and off New Jersey and Maryland.

The various foreign participants in this fishery have manifested some negative interactions.

Japan: U. S. swordfishermen report the sighting of dead and mutilated swordfish where Japanese tuna longlines have been fishing. They are concerned about the loss of swordfish to the domestic fishery as a result of Japanese tuna longlining activities in the FCZ. They also report gear conflicts arising from failure of the Japanese to mark their longline with radar reflectors so that it can be seen at night. Consequently, gear tangles occur often resulting in loss of portions of the line. In addition, recent reports of extreme congestion on the fishing grounds, as well as direct damage to domestic gear by foreign vessels have been received by the Councils. Sports fishermen are also affected by the Japanese activities, and those fishing in the northern Gulf of Mexico report a decline in billfish catches which they link to the Japanese longlining fishing activities.

*Japan has agreed not to fish in the Gulf of Mexico during 1982 and 1983.

Canada: The Canadian fishery for swordfish officially reopened in 1979 under a quota system. At present Canadian swordfishing vessels do not have access to the U.S. FCZ. Canada plans to issue licenses to foreign vessels wishing to enter Canadian waters to purchase swordfish. Purchased Canadian swordfish will compete directly on the market with domestically caught fish. Prior to the official reopening of the Canadian fishery for swordfish in 1979, some Canadian vessels fished for swordfish without the sanction of the Canadian government and sold the catch to American vessels at sea. The Canadian catch was then landed at American ports as U.S. caught fish. Many fishermen report that the Canadian fish entering the U.S. under these conditions is of substandard quality and they feel that this adversely affects the market for their own fish.

- Other Countries: Fishermen report that activities of Spanish, Korean and Taiwanese vessels affect their catch and their freedom of swordfish fishing.

Fishing activities by foreign participants sometimes exert positive effects. These may manifest themselves in various forms. In the case of swordfish, Canadian fishing activities, prior to 1971, have resulted in the generation of data which are now being used in the understanding of this fishery. The Canadian fishing activities have also resulted in the sponsoring of many research activities including cooperative programs with U.S. research personnel. Furthermore, the Japanese longliners have provided considerable catch and effort data.

8.4.6 Interactions With Other Fisheries

The swordfish fishery interacts with foreign trawling for squid (Section 8.4.4), foreign longlining for tuna (Section 8.4.4), domestic longlining for tuna and the domestic recreational billfish fishery. The domestic longline fishery has recently begun to target tuna when the catches of swordfish are low and/or during high abundance of tuna (S. Berkeley, Research Associate, University of Miami, Miami, FL; pers. comm.).

By far, the most important interaction will be with the Atlantic billfishes. The five council billfish FMP defines OY as follows (Draft Fishery Management Plan and Regulatory Impact Review, February, 1982): "Optimum yield for billfishes is the amount of fish caught by the domestic fisheries in the FCZ and territorial sea pursuant to the provisions of the management plan."

8.5 Description of Economic Characteristics of the Fishery*

8.5.1 Domestic Harvesting and Processing Sector

8.5.1.1 Harvesting

The following tables (Tables 8-30 and 8-31) indicate ex-vessel prices as calculated from NMFS data 1960-80. Note that price had the most significant increase in 1972 after the FDA mercury concentration criteria virtually eliminated imports.

Ex-vessel prices vary considerably over the years. They are lowest in the summer with the increase in domestic production from New England landings. Prices also vary by size fish because there is a market preference for larger "steaks." Size classes and average range in price per pound for each weight class in 1978 are shown in Table 8-32. Prices generally increase approximately 25 cents per pound by each size classification (small, medium, large). Prices reported in Florida in 1979 were $1.52/pound for small, $1.82/pound for medium, and $2.08/pound for large (Cato and Lawlor, 1981). "Chunks" of partial swordfish (e.g., after shark attack) sell for negotiated prices normally below the small fish price.

Monthly swordfish ex-vessel price per pound dressed weight for the Florida East Coast is shown in Table 8-33. The mean prices were $2.30 per lb for 100+, $2.05 for 50-99 lb, $1.80 for 25-49 lb, and $1.55 for under 25 lb. Prices for 1981 followed the same general seasonal trend but averaged $1.00 per lb more for each size category (S.A. Berkeley, Research Associate, Univ. of Miami, Miami, FL; pers. comm.).

Harpooned fish command a higher price than longlined fish. Data gathered by NMFS on average value of harpooned versus longlined swordfish landed in New Bedford are shown in Table 8-34. The price differential shown by the data reflects both the higher value placed on harpooned fish as well as the fact that harpooned fish are larger on the average than longlined fish. During 1981, harpooned swordfish received a premium of $.25-$.75 per lb over the general swordfish price of $3.12-$4.00 per lb (E. Mills and F. Hoxsie, New England Advisory Panel; pers. comm.).

In northern waters, large swordfish represent a larger percentage of the catch. In the Gulf of Mexico, swordfish are expected to have a smaller size distribution or contain a larger percentage of smaller fish. The effect this has on percent of revenue (by size fish) for a Florida boat is shown in Table 8-35.

*See Holt (1978) for a socio-economic discussion of the California harpoon fishery.

Table 8-30. Historical swordfish prices by council area by gear type. (Source: Calculated from landings data in Appendix A.)

	NEFMC							MAFMC							SAFMC		GMFMC		ALL AREAS
	H	LL	TROLL LINE	FLOATING TRAP	HAND LINE	FISH TRAWL	AVG	H	LL	OTTER TRAWL	FISH TRAWL	HAND LINE	LOBSTER TRAWL	AVG	LL	AVG	LL	AVG	AVG PRICE
1960	0.40		0.36				0.38		0.54					0.54					0.46
1961	0.39		0.43	0.10			0.31	0.46		0.44				0.45					0.38
1962	0.44	0.42					0.43	0.54	0.61					0.58					0.51
1963	0.24	0.25					0.25	0.38	0.44	0.32				0.38	0.54	0.54			0.39
1964	0.24	0.30					0.27	0.33	0.34		0.27			0.31	0.48	0.48			0.35
1965	0.41	0.38					0.40	0.34	0.42		0.32			0.36	0.54	0.54			0.43
1966	0.45	0.39					0.42	0.43	0.46					0.45	0.50	0.50			0.46
1967	0.42	0.37					0.40		0.39					0.39					0.40
1968	0.53	0.45					0.49		0.49			0.46		0.48					0.49
1969	0.60	0.37	0.75				0.57	0.44	0.45			0.37		0.42			0.90	0.90	0.63
1970	0.62	0.52	0.86		0.76		0.69		0.55			0.55		0.55			0.72	0.72	0.65
1971	0.97						0.97	0.50					0.38	0.44			0.40	0.40	0.60
1972	1.41	1.34					1.38												1.38
1973	1.73	1.23				1.13	1.36	0.84	1.68					1.26			1.00	1.00	1.21
1974	1.22	0.87					1.05		1.40					1.40			1.73	1.73	1.39
1975	1.27	1.23					1.25		1.76					1.76			1.72	1.72	1.58
1976	1.60	1.31					1.46		1.61					1.61					

Table 8-31. Swordfish prices by council area for the years 1977-1980. (Source: NMFS, prelim. data.)

	NEFMC & MAFMC			SAFMC					GMFMC						ALL AREAS
	ME-NJ	DE,MD,VA	AVG	NC	SC	GA	FL.E. COAST	AVG	FL.W. COAST	AL	MS	LA	TX	AVG	AVG
1977	N/A	1.61	1.61	1.75	-	-	1.52	1.64	0.99	-	-	-	-	0.99	1.41
1978	1.30	1.51	1.41	1.52	1.41	2.00	1.76	1.64	1.78	-	-	-	-	1.78	1.61
1979	1.55	N/A	1.55	1.49	1.23	-	2.08	1.60	1.82	-	-	-	N/A	1.82	1.66
1980	1.79	N/A	1.79	1.44	1.37	-	1.50	1.44	2.50	-	-	-	N/A	2.50	1.91

Table 8-32. Ex-vessel price ranges for the various swordfish weight classes in 1978. (Source: American Swordfish Association as given in Booz et al., 1980)

Swordfish Size (lb)	Price Range ($)
0-25	0.90-2.40
26-49	1.10-2.60
50-99	1.30-2.80
100+	1.50-3.00

Table 8-33. Approximate ex-vessel price per pound dressed weight of swordfish by size and month on the Florida East Coast, 1980. (Source: S.A. Berkeley, Research Associate, Univ. Miami, Miami, FL; pers. comm.).

MONTH	WEIGHT CLASS (lb)			
	100+	50-99	25-49	Under 25
Jan	3.20	2.95	2.70	2.45
Feb	2.90	2.65	2.40	2.15
Mar	2.70	2.45	2.20	1.95
Apr	2.50	2.25	2.00	1.75
May	2.20	1.95	1.70	1.45
June	2.10	1.85	1.60	1.35
July	1.90	1.65	1.40	1.15
Aug	1.80	1.55	1.30	1.05
Sept	1.70	1.45	1.20	0.95
Oct	1.60	1.35	1.10	0.85
Nov	2.20	1.95	1.70	1.45
Dec	2.80	2.55	2.30	2.05
Mean	$2.30	$2.05	$1.80	$1.55
Standard Deviation	0.52	0.52	0.52	0.52

Table 8-34. Ex-vessel price for harpooned versus longlined swordfish from 1974 to 1978, New Bedford, Massachusetts, swordfish summary. (Source: NMFS)

	Harpooners				Longliners			
	Trips	Pounds	Value ($)	Average Price[a] ($/lb)	Trips	Pounds	Value ($)	Average Price ($/lb)
1978 (Jan.-July)	24	213,952	424,618	1.98	5	110,518	183,150	1.66
1977	60	249,013	423,355	1.70	16	397,403	593,641	1.49
1976	50	203,866	393,830	1.93	48	815,900	1,378,156	1.69
1975	39	244,195	380,418	1.56	54	836,353	1,231,190	1.47
1974	32	267,588	351,742	1.31	18	453,837	479,373	1.06

a. Average price differential favoring harpooners primarily reflects larger size and secondarily reflects premium for harpooned fish.

Table 8-35. Revenue by size fish from a 36-foot swordfish vessel using a 10 mile longline on the South Florida Atlantic Coast, 1979. (Source: Cato and Lawlor, 1981)

	$/lb	Total pounds (lb)	Total revenue ($)	Percent of Revenue
Large Swordfish	2.08	45,834	95,308	69
Medium Swordfish	1.82	16,161	29,485	21
Small Swordfish	1.52	8,631	13,112	10
TOTALS		70,626	137,905	

Share systems are the common method of payment for commercial fishermen. In New England, these share systems are formally written in the contracts for the unionized fishermen but similar share systems are in use for nonunionized fishermen. Smith and Peterson (1977) have provided a description of conventional share systems in use in New England. The share system specifies which costs are to be taken out of the gross revenues, subtracts them and then divides the remainder between the boat owner and the crew according to a predetermined ratio. A number of expenses are subtracted from the crew share before it is divided. A typical system is the 50/50 split. In this system, operating expenses for fuel, ice, food, etc., are subtracted from gross revenues. The captain receives 10 percent of the amount remaining after expenses have been subtracted. Half of the remainder goes to the boat owner, and the other half is divided among the crew. Share systems are the typical method of payment for the large swordfish vessels. Small vessels, with only one or two crew members, may be paid by other methods, such as a flat fee or a percentage of total earnings.

The typical method of crew share in the small boat longline fishery on Florida's East Coast is as follows (Cato and Lawlor, 1981): "...trip expenses for bait, lights, ice, fuel, batteries, groceries and miscellaneous costs to be deducted from total revenues with the remainder divided among the boat (40 percent) and the captain and crew (60 percent). The 60 percent is then divided by the captain (35 percent), first mate (15 percent) and crewman (10 percent)."

Share systems associated with shrimp vessels converting to swordfish longlining for a portion of the year are discussed in Section 8.5.1.3.

During 1979, the necessary investment capital to enter the small-boat swordfish longline fishery on the South Florida Atlantic Coast was approximately $77,000 (Table 8-36). A sample costs and return budget for a boat of this size using a 10-mile longline is shown in Table 8-37.

The 36 foot Florida swordfish boat earned $142,327 in 1979. Fixed costs were $16,255, variable costs $70,259 (including crew share) (Table 8-37). Net revenue to owner/captain was $55,813 of which $39,044 was captain's share and $16,769 was a 22 percent return on a total investment of $76,855 (Table 8-37).

Table 8-36. Estimated value of a 36-foot swordfish vessel using a 10-mile longline on the South Florida Atlantic Coast, 1979 (Source: Cato and Lawlor, 1981).

Item		1979 Value[c]		19__ Value[b]
		———Dollars———		
Hull		47,250		____
Engine		11,000		____
Electronics[a]				
fathometer (2 @ 500)	1,000		____	
radar	5,000		____	
loran	2,000		____	
VHF	500		____	
single side band	500		____	
CB	100			
	____	9,100		____
Longline				
reel and leader cart	3,500		____	
hiflyers (.8 per mile) including strobe, rod, radar reflector, buoy	1,200		____	
tarred main line - 53,300 feet (5,330 per mile)	2,239		____	
100-foot drops, 250 feet apart, from buoys and hiflyers - 21,200-foot line	742		____	
bullet buoys, 203 (20.3 per mile)	609		____	
gangions, 200, 150 feet each monofilament (20 per mile)	700		____	
snaps, 409 (40.9 per mile)	385		____	
hooks, 200 (20 per mile)	130		____	
		9,505		____
Total investment		76,855		

[a]Some boats do not use this full array of electronic equipment and thus costs may vary slightly among boats.

[b]This column can be used to estimate cost in a future year.

[c]These values represent used values of the vessel and equipment except for the longline. Replacement values would be higher.

Table 8-37. Costs and returns budget for a 36-foot swordfish vessel using a 10-mile longline on the South Florida Atlantic Coast, 1979. (Source: Cato and Lawlor, 1981).

	1979							19 Budget[c]				
	Price per Pound (Dollars)	Number of fish: Total	Number of fish: Per Trip[a]	Pounds or Units: Total	Pounds or Units: Per Trip[a]	Dollars: Total	Dollars: Per Trip[a]	Units or Pounds per Trip x	Number of trips x	Price or Cost per Pound or Unit =	Total Revenue or Cost	Revenue or Cost per Trip
								Dollars				
Revenue												
Large swordfish	2.08	257	2.9	45,834	533	95,308	1,108					
Medium swordfish	1.82	224	2.6	16,161	188	29,485	343					
Small swordfish	1.52	260	3.0	8,631	100	13,112	152					
Total		741	8.6	70,626	821	137,905	1,603					
Swordfish chunks	1.50	26	.3	1,331	15	1,998	23					
Tuna	.82	34	.4	2,142	25	1,751	20					
Other	.89	—	—	759	9	673	8					
Total		801	9.3	74,858	870	142,327	1,654					
Expenses:												
Variable												
Bait (pounds)				11,024	128	6,134	71					
Cyalume lights (number)				12,900	150	10,191	119					
Ice (pounds)				28,566	332	592	7					
Fuel (gallons)				10,320	120	8,978	104					
Batteries (number)				1,290	15	889	10					
Groceries				—	—	3,440	40					
Misc. (gloves, saws, etc.)						550	6					
Crewshare						27,888[d]	324					
Longline repairs and maintenance												
mainline reel (feet)				7,980	93	336	4					
gangions				43	1	2,408	28					
Bullet buoys (number)				30	(b)	90	1					
hooks (number)				2,580	30	1,548	18					
strobes (number)				860	10	99	1					
Hiflyers (number)				2	(b)	360	4					
snaps (number)				860	10	808	9					

Continued

Table 8-37. (continued)

	Price per Pound (Dollars)	1979 Number of fish Total	Number of fish Per Trip[a]	Pounds or Units Total	Pounds or Units Per Trip[a]	Dollars Total	Dollars Per Trip[a]	19__ Budget[c] Units or Pounds per Trip x	Number of trips x	Price or Cost per Pound or Unit =	Total Revenue or Cost	Revenue or Cost per Trip
										——Dollars——		
buoys drops (feet)				2,120	25	74	1	___	___	___	___	___
miscellaneous						300	3	___	___	___	___	___
Vessel repair and maintenance												
hull						2,362	27		___	___	___	___
engine						1,100	13		___	___	___	___
electronics					___	2,112	25	___	___	___	___	___
Total variable costs						70,259	817					
Fixed												
Depreciation												
longline						3,168	37				___	___
hull						3,225	38				___	___
engine						1,143	13				___	___
electronics						2,916	34				___	___
Insurance						2,660	31				___	___
Interest						2,659	31				___	___
Dockage						432	5				___	___
Vessel registration					___	52	1			___	___	___
Total fixed costs						16,255	189				___	___
Total Costs						86,514	1,006				___	___
Net Revenue to owner/captain's crewshare, management and capital						55,813	649				___	___

[a]Totals may not add due to rounding. Average number of trips was 86.

[b]Less than one half.

[c]This column can be used in a future year.

[d]Does not include captain's share of $39,044. This is included in the net revenue to owner/captain of $55,813.

8.5.1.2 Processing

Swordfish are normally dressed at sea by the fisherman who removes the head and tail, guts the fish and scrubs out the body cavity. The only additional processing required before the fish reaches the consumer is the removal of the center bone and cutting into steaks. Waste is only 10 percent to 20 percent of the dressed weight of the fish. Steaks which are not to be sold fresh chilled are frozen.

Only eight processors of swordfish, all located in New England, are listed in "Processors of Fishery Products in United States," 1976, published by the National Marine Fisheries Service, Washington, D.C. Many other fish processors handle swordfish but have been reluctant to admit it. Thus, actual numbers of processors and wholesalers of swordfish are not known at this time.

A total of 1,196 fish processing establishments operated on the Atlantic and Gulf coasts in 1979 (U.S. Department of Commerce, Fisheries of the U.S., 1980). Plants involved in processing fish fillets and steaks numbered 127 in 1977, 146 in 1978, 158 in 1979, and 167 in 1980. Smith and Peterson (1977) report that a substantial number of the fish processing plants in New England have underutilized capacity.

8.5.1.3 Probability of Increasing Fishing Effort

Business decisions to convert existing fishing vessels to longline swordfishing are based on the relative attractiveness of swordfishing compared to alternative fisheries. In the South, the poor economic condition in the shrimp fishery offers the largest number of potential immediate conversions. Many shrimpers in the Gulf of Mexico have attempted swordfish longlining. However, because of travel distance, weather conditions, and other factors, most of the Gulf shrimpers are now finding more success with closer inshore bottom longlining for snapper amd grouper. Commercial snapper/grouper landings compared to swordfish landings in Texas reflect this trend (Orman Farley, NMFS; pers. comm.).

It has been estimated that small boat longlining on the East Coast of Florida can be more profitable than mackerel fishing for an equivalent boat (James Cato, Associate Professor, Univ. FL, Gainesville, FL; pers. comm.). However, it is also recognized that the fishing conditions are quite different. Longlining is further offshore, requiring multiple days of night fishing; considerably more stress is placed on the crew and boat than most other types of commercial fishing.

Mackerel Boat-Type Conversions

Cato and Lawlor (1981) report that "boats used in the King and Spanish mackerel fishery and the spiny lobster fishery could be converted to swordfishing with minimal physical changes." As an example, estimated costs and returns for a large Lower Florida Atlantic Coast mackerel net boat were given (Table 8-38). They analyzed the changes as follows:

Increased Costs		Decreased Costs	
Bait	$ 6,134	Fuel (12,211 - 8,978)	= $ 3,233
Cyalume lights	10,191	Crewshare (51,324 - 27,888)	= 23,436
Batteries	889	Spotter plane	7,852
Groceries	3,440	Ice (2,536 - 592)	= 1,944
Longline r & m	6,023	Gear (1,443 - 550)	= 893
Longline depreciation	3,168	Net r & m	1,784
		Net depreciation	7,094
Decreased Income		**Increased Income**	
	0	Fish sales	
		(142,327 - 130,870)	= $11,457
Loss effect	$29,845	Gain effect	$57,693

Gain effect	$57,693
Loss effect	-29,845
Profit from change	$27,848

Table 8-38. Estimated costs and returns for large lower Florida Atlantic Coast mackerel net boats, 1979. (Source: Cato and Lawlor, 1981)

Item		Dollars
Revenue		
king mackerel		25,760
Spanish mackerel		59,764
other fish		45,346
Total		130,870
Variable Costs		82,352
fuel and oil	12,211	
crewshare and picking labor	51,324	
spotter plane	7,852	
ice	2,536	
raingear and gloves	1,443	
hull and engine repair and maintenance	4,888	
net repair and maintenance	1,784	
electronics repair and maintenance	314	
Fixed Costs		18,407
hull and engine depreciation	6,269	
electronics depreciation	363	
net depreciation	7,094	
insurance, interest, registration, dockage	4,681	
Total Costs		100,759
Net returns to owner's labor, management and investment		30,111

"By changing to swordfishing, the former mackerel fisherman realizes an additional $11,457 in income. Decreased costs resulted from using less fuel, ice and gear, paying a smaller crewshare, not requiring a spotter plane, and not having expenses for net repair and maintenance and net depreciation. Increased costs resulted from bait, cyalume lights, batteries and groceries. Costs will also be incurred from longline repair and maintenance and from depreciating the newly acquired longline and reel. The net effect of switching is then $27,848. This analysis means the mackerel fisherman will make an additional $27,848 by making the switch for a total income of $57,959. This result is slightly higher than that earned from the 36 foot swordfish boat. The larger vessel will consume more fuel than the smaller vessel. However, this difference was not calculated for this partial budget analysis."

Shrimper-Type Conversions

The only published information available on this type of conversion is from the Gulf of Mexico in a study by Nichols et al. (1980). The following tables and much of the discussion is taken directly from this work. For further information please see the original article (reference contained in Section 9.0).

The initial total investment expenditure for equipping a 75 foot shrimp vessel with 19 miles of longline gear ranged from $26,105 without radio beacons to $31,105 with radio beacons (Table 8-39).

Nichols et al. (1980) assumed a basic operating concept as follows: (1) a seasonal fishing activity with the summer months devoted entirely to shrimping and winter months entirely to swordfish longlining; (2) in some years the cash flow to shrimping can be quite high through November and December, but these are also important months for swordfishing; (3) for this analysis the shrimping season extends from May through October and swordfishing begins in November and runs through April; (4) once the swordfish activity leaves the Gulf after April, the fishing activity of the fishermen is again directed toward shrimp; (5) using available shrimp historical monthly cash flow data it was found that roughly 39 percent of the revenue was earned by the shrimper during the November-April period

Table 8-39. Initial investment expenditure for equipping a 75 foot shrimp vessel with 19 miles of longline gear, Spring 1980. (Source: Nichols et al., 1980)

	Cost/Unit		Amount	Value
1. Fishing Gear				
Line	$ .04	per ft	115,000 ft	$ 4,600
Monofilament	8.00	per lb	80 lbs	640
Hooks	.50	ea.	1,500	750
Snaps	.91	ea.	1,100	1,001
Floats				
30 inch	7.00	ea	200	1,400
50 inch	25.00	ea.	20	500
Hiflier poles	24.00	ea.	20	480
Radar reflectors	12.00	ea.	20	240
Strobe lights	50.00	ea.	10	500
Chemical light stocks	.90	ea.	3,000	2,700
Knives	7.00	ea.	4	28
Batteries for Strobe lights	1.00	ea.	36	36
Rubber bands				6
Lead Ballast	.50	per lb	100 lbs	50
Subtotal, Fishing gear (19 miles)				$12,920
Radio beacons (optional)	$5,000.00	per set	1 set	5,000
Subtotal, Fishing gear with radio beacons (19 miles)				$17,920
2. Deck or Dry Equipment				
Winch installation				
winch	$6,500.00	ea.	1	$ 6,500
parts and labor	$1,500.00			1,500
Subtotal, winch installation				$ 8,000
Fairlead blocks	30.00	ea.	2	60
Gangion spools	60.00	ea.	7	420
Gaffs	30.00	ea.	2	60
Baiting table	75.00	ea.	1	75
Buoy racks or cages	400.00	ea.	1	400
Subtotal, Deck Equipment				$ 9,015

Table 8-39. (continued)

	Cost/Unit	Amount	Value
3. Electronic Equipment			
Water temperature gauge	$ 350.00 ea.	1	$ 350
Subtotal, Electronic Equipment			$ 350
4. Structural Modifications			
Cutting bulwarks			$ 50
Enlarging crew quarters			1,700
Installing steering station			2,000
Sectioning boat			70
Subtotal, Structural Modifications			$ 3,820
Total investment expenditure (without radio beacons)			$26,105
Total investment expenditure (with radio beacons)			$31,105

while approximately 41 percent of the costs were accrued during this time. The budget shown in Table 8-40 reflects these costs and returns divided seasonally; (6) landings reflected for the May-October period is 61 percent; and (7) the crew share allowed some of the variable costs to be assumed by the crew. Under this arrangement the cost of ice and packing are deducted from the total revenue figure. Then the remaining revenue is divided such that the crew receives 40 percent and the owner receives 60 percent. The crew is responsible for groceries, any personal expenses, and also, 20 percent of the fuel costs.

The budget shown in Table 8-40 shows a positive return above variable costs for both seasons but a loss of $32,503 for the year when all fixed costs are included. It is important to note that the November-April period results in a positive return above variable costs of $3,806 and any alternative activity such as swordfishing should yield at least this much as a contribution towards fixed costs.

These partial budgets were developed by Nichols et al. (1980) because the costs incurred by the owner, crew and captain are different.

For the swordfish analyses it was assumed that (Nichols et al., 1980) (1) the average catch was 600 lb per day; (2) the average size during the spring of 1980 in the Gulf was estimated to be 65-70 lb; (3) the average ex-vessel price for this size swordfish was $2.60 per lb; (4) the vessel had already been purchased and used as a shrimp boat; (5) all depreciation and interest on the vessel itself were charged against the shrimping side of the operation; and (6) there were no changes in the rates of depreciation as a result of the longlining. In addition, under the crew share arrangement most prevalent among Texas longliners in early 1980, the captain received five percent of the catch as a bonus. Then the remainder of the catch was divided such that the boat got 40 percent of the remaining 95 percent or 38 percent of the total catch; the crew got 60 percent of the remainder or 57 percent of the total catch. The crew is responsible for the bait, ice, fuel, replacement of damaged or lost line, groceries, light sticks, and their share (57 percent) of the freight and handling on the fish. This crew share arrangement shifts the risk of the trip from the owner of the boat to the crew. For this reason, there has been experimentation with alternative share arrangements. One alternative is a 50-50 split between boat and crew.

Table 8-40. Estimated average cost and returns by seasons for the owner of a 75 ft Gulf shrimp vessel, 1979-80[1/] (Source: Nichols et al., 1980)

Revenue and Cost Items	November-April	May-October	Total
1. Gross receipts (shrimp)			
30,500 @ 3.00		$91,500	
19,500 @ 3.00	$58,500		
Total			$150,000
2. Variable Costs			
Ice	1,120	1,612	
Fuel	15,773	23,861	
Nets and supplies	6,516	10,191	
Repair and maintenance	6,715	9,663	
Crew share	23,400	36,600	
Packing	1,170	1,830	
Total	54,694	83,757	138,451
3. Return above variable cost	3,806	7,743	11,549
4. Fixed Costs			
Insurance			7,073
Depreciation			10,833
Overhead			5,896
Interest			20,250
Total Fixed Costs			44,052
5. Total Costs			182,503
6. Return to owner's equity and management			-32,503

1/ Share arrangement as follows: ice and packing are taken off the top (shared proportionally); remaining revenue is shared, with owner receiving 60 percent and crew 40 percent; crew pays for groceries, personal expenses and 20 percent of fuel.

Estimated costs and returns for the owner, crew and captain are shown in Tables 8-41, 8-42 and 8-43 respectively. The return to the owner was $46,786, $33,611 to a crew of five and a bonus of $13,622 to the captain.

Budgets for a joint shrimp/swordfish season are shown for owner and crew in Tables 8-44 and 8-45; both reflect positive returns, $10,477 to the owner and $58,742 to the crew.

Finally, a breakeven analysis was performed by Nichols et al. (1980) to calculate either the price or the quantity necessary for the operation to exactly cover all costs or to just "breakeven." Separate analyses were made for the owner and crew because both pay part of the expenses under the assumed swordfishing share system. (See Nichols et al., 1980 for the basic formula used in calculating the breakeven price and quantity.) Estimated breakeven prices for swordfish at alternative levels of landings, for owner and crew and with a 60/40 share arrangement indicated a price of between $0.64 - $2.14 assuming a catch of 600 lb per night (Table 8-46). Estimated breakeven landings assuming an average price of $2.60 per lb ranged from 10,473 - 46,504 lb in the six month season (Table 8-47). The combined relationship of price and quantity is shown graphically in Figure 8-13.

As mentioned previously, the 50/50 share arrangement is gaining popularity and estimated breakeven prices assuming an average landing of 57,600 lb during the six month season ranged between $1.06 and $2.01 per lb (Table 8-48). A graphical presentation of the price/quantity relationship is shown in Figure 8-14.

In conclusion, estimates for 1980 (Nichols et al., 1980) indicated that swordfish longlining could be sufficiently profitable to turn a negative cash flow from shrimping into a positive annual cash flow (shrimping and swordfishing). However, available data indicate swordfish longlining in 1981 did not produce sufficient profits to result in a positive annual cash flow (J. P. Nichols, Professor, Texas A&M Univ., College Station, TX; pers. comm.).

Table 8-41. Estimated average 1980 cost and returns for the owner of a 75 ft Gulf vessel engaged in swordfish longlining for a six month period. (Source: Nichols et al., 1980)

Revenue and Cost Items	Value	Total
1. Gross receipts from operation		
Swordfish—57,600 lb @ $2.60	$149,760	
Total returns		$149,760
2. Share accruing to owner (38%)		
Swordfish—21,888 lb @ $2.60	56,909	56,909
3. Variable Costs		
Freight & handling		
Swordfish—21,888 lb @ $.20	4,378	
Winch and electronic maintenance	600	
Equipment expense	1,015	
Total variable costs		5,993
4. Returns above variable costs		50,916
5. Fixed Costs[1]		
Depreciation	1,604	
Interest	2,520	
License	6	
Total Fixed Costs		4,130
6. Total Costs		$ 10,123
7. Returns to Boat's fixed costs, owner's equity and management		$ 46,786

1 This includes only fixed costs directly associated with longlining enterprise.

Table 8-42. Estimated average 1980 cost and returns for the crew of a 75 ft Gulf vessel engaged in swordfish longlining for a six month period. (Source: Nichols et al., 1980)

Revenue and Cost Item	Value	Subtotal	Total
1. Gross receipts from operation			
Swordfish—57,600 lb @ $2.60	$149,760		
Total returns			$149,760
2. Share accruing to crew (57%)	85,363		85,363
3. Variable Costs			
Ice - 960 bars @ $4.00	3,840		
Fuel - 12,000 gal @ $.90	10,800		
Groceries - 8 trips @ $600	4,800		
Bait - 40,000 lb @ $.36	14,400		
Light sticks - 11,136 sticks @ $.90	10,022		
Subtotal, Variable		$43,862	
Replacements			
Line - 10,032 ft @ $.04	401		
Monofilament - 8 lb @ $8.00	64		
Hooks - 150 @ $.50 ea.	75		
Snaps - 110 @ $1.01 ea.	111		
Bar buoys - 2 @ $36.50 ea.	73		
Net buoys - 24 @ $7.00 ea.	168		
Strobe lights - 1 @ $50.00 ea.	50		
Hiflier poles - 2 @ $25.00 ea.	50		
Radar reflectors - 2 @ $15.00 ea.	30		
Batteries, knives, weights, and rubber bands	302		
Subtotal, Replacement		$ 1,324	
Freight & handling - 32,832 lb @ $.20		$ 6,566	
Total Variable Costs			$ 51,752
4. Return to Crew (5 members)			$ 33,611
Return to individual members of the crew			$ 6,722

Table 8-43. Estimated average 1980 costs and returns for a captain of a 75 ft Gulf vessel engaged in swordfish longlining for a six month period. (Source: Nichols et al., 1980)

Revenue and Cost Items	Value	Total
1. Gross receipts from operation		
Swordfish - 57,600 lbs. @ $2.60	$149,760	
Total returns		$149,760
2. Share accruing to captain (5%)		
Swordfish - 2,880 lbs. @ $2.60	7,488	
Return to captain as a crew member	6,710	
Total returns to captain		14,198
3. Variable costs		
Freight & handling swordfish - 2,880 lbs. @ $.20	576	
Total variable costs		576
4. Net returns to captain		$ 13,622

Table 8-44. Estimated average 1980 annual costs and returns for the owner of a 75 ft Gulf vessel engaged in six months of shrimping and six months of longlining.[1/] (Source: Nichols et al., 1980)

Revenue and Cost Items	Value	Total
1. Gross receipts from operation		
Shrimp (owner's share)—		
18,300 lbs. @ $3.00	$54,900	
Swordfish (owner's share)—		
21,888 lbs. @ $2.60	56,909	
Total Returns to Owner		$111,809
2. Variable Costs		
Ice—403 bars @ $4.00	1,612	
Fuel—26,512 gals @ $.90	23,861	
Nets & Supplies	10,191	
Repair & maintenance	10,263	
Packing, freight & handling	6,208	
Equipment expense	1,015	
Total Variable Costs		$ 53,150
3. Returns to Owner above variable costs		$ 58,659
4. Fixed Costs		
Fishing license	6	
Depreciation	12,437	
Insurance	7,073	
Interest	22,770	
Overhead	5,896	
Total Fixed Costs		$ 48,182
5. Total Costs		$101,332
6. Returns to Fixed Cost, Owner's Equity & Management		$ 10,477

[1/] Calculated from Tables 8-40 and 8-41.

Table 8-45. Estimated average 1980 annual costs and returns for the crew of a 75 ft Gulf vessel engaged in six months of shrimping and six months of swordfish longlining.[1] (Source: Nichols et al., 1980)

Revenue and Cost Items	Value	Total
1. Gross receipts from operation		
Shrimp (Crew's share)—		
12,200 lb @ $3.00	$36,600	
Swordfish (Crew's share)—		
32,832 lb @ $2.60	85,363	
Total returns to crew		$121,963
2. Variable Costs		
Bait—40,000 lb @ $.36	14,400	
Fuel—18,628 gal @ $.90	16,765	
Ice—1,229 bars @ $4.00	4,916	
Groceries	7,950	
Light sticks—		
116/day or 11,136 @ $.90	10,022	
Replacement	1,382	
Packing, freight & handling		
Shrimp—12,200 lb @ $.10	1,220	
Swordfish—32,832 lb @ $.20	6,566	
Total variable costs		$ 63,221
3. Returns to crew		$ 58,742

[1] Calculated from Tables 8-40 and 8-42.

Table 8-46. Estimated breakeven prices for swordfish at alternative levels of landings, owners and crew with 60/40 share arrangement, Texas, 1980. (Source: Nichols et al., 1980)

Quantity		Breakeven price per pound			
		Requirements for Vessel Owner		Requirements For Crew	
Per Night	Per Season[1]	Returns to Shrimping Alternative	Including one-half vessel fixed costs	Without opportunity cost	With opportunity cost
pounds		dollars			
100	9,600	2.81	7.81	8.46	11.83
200	19,200	1.51	4.00	4.33	6.01
400	38,400	.85	2.10	2.26	3.10
600[2]	57,600	.64	1.47	1.57	2.14
800	76,800	.53	1.15	1.23	1.65
1000	96,000	.46	.96	1.03	1.36
1200	115,200	.42	.83	.89	1.17
1400	134,400	.39	.74	.79	1.03

1 Season is assumed to consist of 8 trips averaging 12 days of fishing each over a six month season.

2 Corresponds with estimated "typical" landings used in preparing cost and returns budgets shown in Tables 8-41 and 8-42.

Table 8-47. Estimated breakeven landings for swordfish at alternative prices, owner and crew, Texas, 1980. (Source: Nichols et al., 1980)

Price per Pound	Breakeven quantity per season[1]: Requirements for Vessel Owner: Returns to Shrimping Alternative	Requirements for Vessel Owner: Including one-half vessel fixed costs	Requirements For Crew: Without opportunity cost	Requirements For Crew: With opportunity cost
dollars	pounds			
1.50	19,344	56,215	60,980	85,854
2.00	13,963	40,599	44,041	62,006
2.20	12,567	36,539	39,637	55,805
2.40	11,425	33,218	36,033	50,732
2.60[2]	10,473	30,450	33,031	46,504
2.80	9,667	28,107	30,490	42,927
3.00	8,976	26,100	28,312	39,861
3.20	8,378	24,360	26,425	37,204
3.40	7,854	22,837	24,773	34,878

1 A season is assumed to consist of 96 fishing days (8 trips average 12 fishing days each) over a six month season.

2 Corresponds with estimated price received for "typical" vessel as used in cost and returns budgets, Tables 8-41 and 8-42.

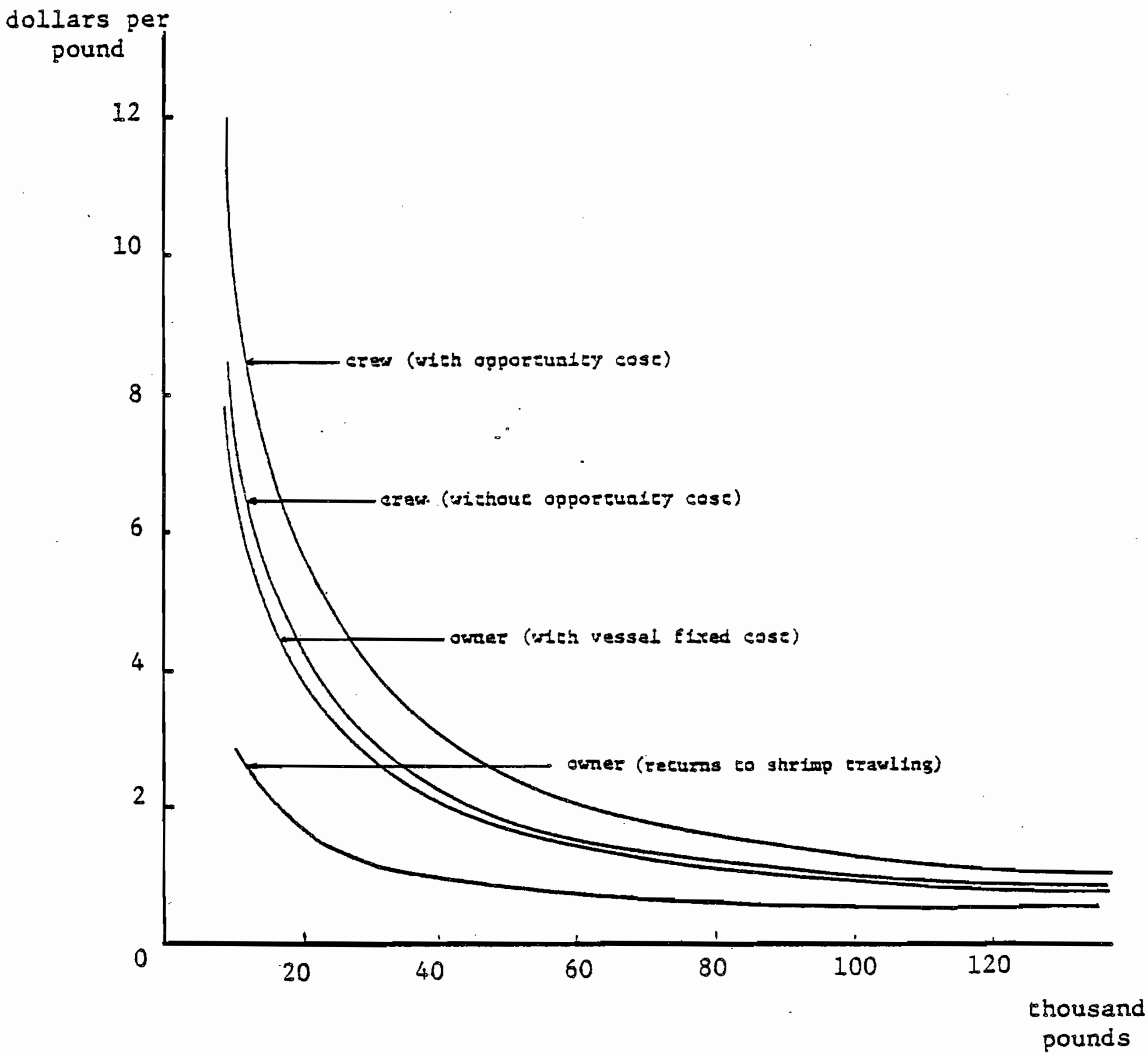

Figure 8-13. Estimated breakeven prices and landings for swordfish longlining with 60-40 crew/owner share system; six months combined with shrimp trawling, Gulf of Mexico, 1980. (Source: Nichols et al., 1980)

Table 8-48. Estimated breakeven prices for swordfish at alternative levels of landings, owners and crew with 50/50 share arrangement, Texas, 1980. (Source: Nichols et al., 1980)

	Breakeven price per pound [1]			
	Requirements for Vessel Owner		Requirements For Crew	
Quantity per Season [1]	Returns to Shrimping Alternative	Including one-half vessel fixed costs	Without opportunity cost	With opportunity cost
pounds		dollars		
9,600	7.07	11.07	5.33	9.37
19,200	3.63	5.63	2.77	4.79
38,400	1.91	2.92	1.48	2.49
57,600 [2]	1.35	2.01	1.06	1.73
76,800	1.06	1.56	.84	1.35
96,000	.89	1.29	.71	1.12
115,200	.77	1.11	.63	.96
134,400	.69	.98	.57	.85

1 Season is assumed to consist of 8 trips averaging 12 days of fishing each over a six month season.

2 Corresponds to estimated "typical" landings used in preparing cost and returns budgets shown in Tables 8-41 and 8-42.

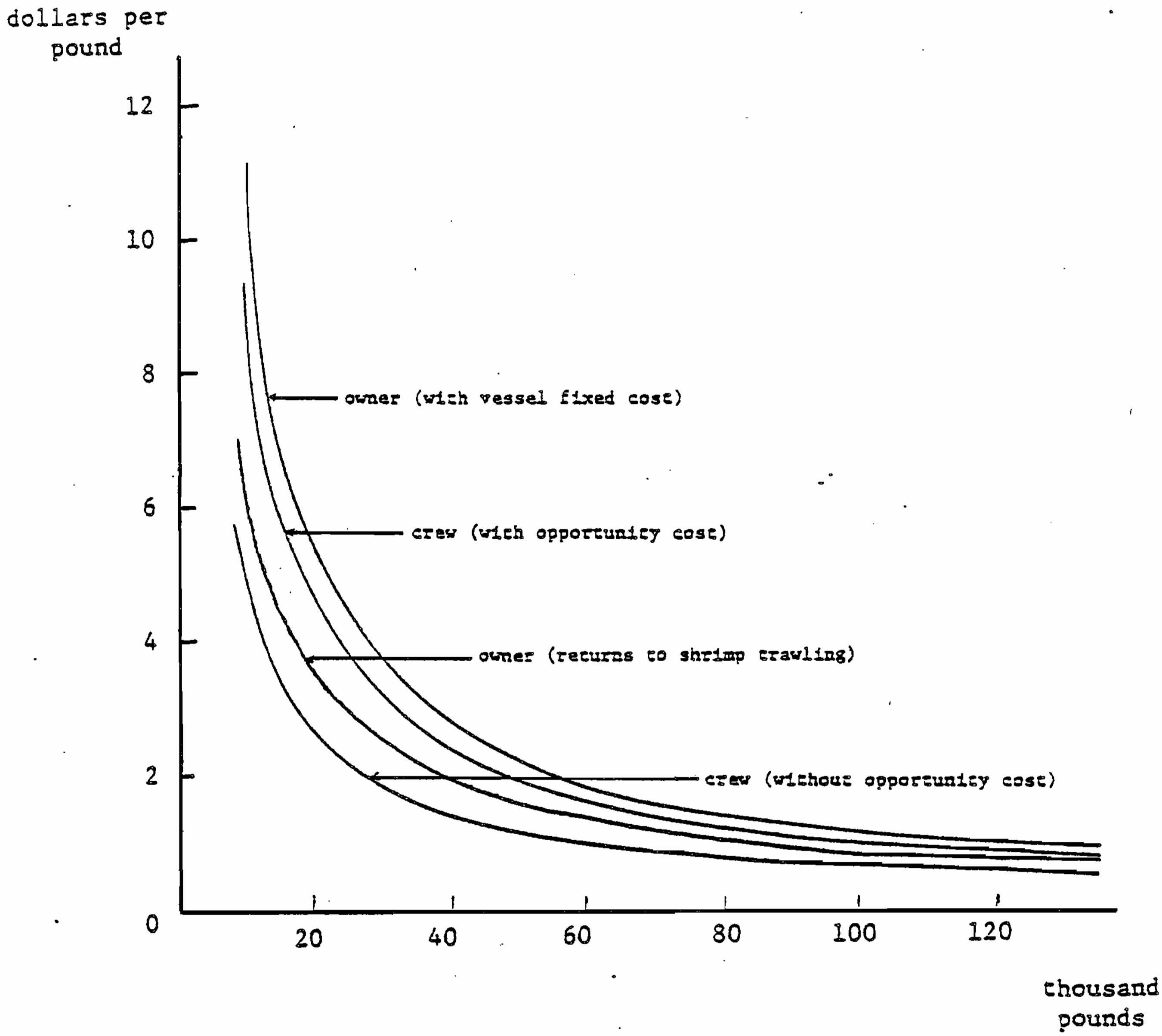

Figure 8-14. Estimated breakeven prices and landings for swordfish longlining with 50-50 crew/owner share system; six months combined with shrimp trawling, Gulf of Mexico, 1980. (Source: Nichols et al., 1980).

Swordfish advisory panel members unanimously agree that profits are declining and that the swordfish fishery is no longer expanding as rapidly. The yield-per-recruit (YPR) model developed by Berkeley and Houde (1980, 1981) also supports decreasing economic returns. Table 8-49 is calculated from the yield-per-recruit model (both sexes). It indicates predicted percent changes in landings with percent increases in fishing effort (as estimated by F level). Expanding effort will not only decrease landings but the resulting smaller average size fish will bring lower dollar value per pound.

When value by size fish is incorporated, total revenue to the industry will decrease with any increasing effort on females or males (Table 8-50).

8.5.1.4 International Trade

From 1960 to 1970, imports accounted for a large portion of total domestic consumption (Table 8-51). After 1970 imports were severely restricted by FDA requirements on mercury content. Restricted imports resulted in a substantial price increase for domestic swordfish.

Although few swordfish are currently being imported or exported, it is recognized that swordfish caught by Canadian boats are being sold to American fishermen at sea, who then land them in the United States (National Fisherman, March 1979). Prices paid to the Canadians for their swordfish are about half the ex-vessel market price in the United States. Some U.S. fishermen express concern over this situation, since they feel that swordfish brought in under these conditions are of inferior quality and tend to drive down prices for their own catches.

Table 8-49. Change in landings and average size with changing fishing effort based on yield-per-recruit model.*

Fishing Mortality (Theoretical F)	Cumulative % Change in F from three base levels			Yield-Per-Recruit		Cumulative % change in Landings from three base levels			Average Size	
				Kilos	Pounds				Kilos	Pounds
.01	- 93.8			3.97	8.75	-83.3			79.40	175.05
.06	- 62.5			15.98	35.23	-32.7			66.58	146.78
.11	- 31.3			21.01	46.32	-11.5			56.78	125.18
.16	Existing			23.75	52.36	Existing			51.63	113.82
.21	+ 31.3	Existing		24.72	54.50	+ 4.1	Existing		46.64	102.82
.26	+ 62.5	+23.8	Existing	25.34	55.87	+ 6.7	+2.50	Existing	43.69	96.32
.31	+ 93.8	+47.6	+19.2	25.42	56.04	+ 7.0	+2.80	+0.01	41.00	90.39
.41	+156.3	+95.2	+57.7	25.16	55.47	+ 5.9	+1.80	-0.01	37.00	81.57
.51	+218.8	+142.8	+96.1	24.63	54.30	+ 3.7	-0.01	-0.03	33.74	74.38
.61	+281.3	+190.4	+134.6	24.36	53.70	+ 2.6	-0.02	-0.04	32.05	70.66
.71	+343.8	+238.1	+173.1	23.75	52.36	0	-0.04	-0.06	30.06	66.27

*Based on yield-per-recruit estimates of Berkeley and Houde (1981) for both sexes combined.

M = .19
K = .0949
L_c = 118 cm (age II, 18.6 kg)
F = .16-.21
F_{max} = .35

Table 8-50. Industry revenue adjusted for value by size fish in the market.

MARKET CATEGORY (dressed weight)	MEAN 1980 Ex-vessel price/lb (Florida)	AGE OF FISH (YR)	
		FEMALES	MALES
PUPS Less than 25 lb	1.55	0.0-1.6	0.0-1.3
SMALL 25-49 lb	1.80	1.6-2.7	1.3-2.8
MEDIUM 50-99 lb	2.05	2.7-4.6	2.8-5.5
LARGE Over 100 lb	2.30	4.6+	5.5+

FISHING EFFORT (F LEVEL)	PERCENT OF FEMALES IN EACH MARKET CATEGORY*				INDEX OF TOTAL REVENUE**	PERCENT CHANGE
	PUPS	SMALL	MEDIUM	LARGE		
0.18	-	20.69	37.93	41.38	12,132	-31.11
0.28	-	31.58	59.21	9.21	8,359	

FISHING EFFORT (F LEVEL)	PERCENT OF MALES IN EACH MARKET CATEGORY*				INDEX OF TOTAL REVENUE**	PERCENT CHANGE
	PUPS	SMALL	MEDIUM	LARGE		
0.17	-	22.76	49.59	27.64	10,614	-17.57
0.88	-	37.04	48.15	14.82	8,749	

*Calculated from survival rates estimated from the YPR parameters (Survival = $(1 - F/Z(1-e^{-Z}))$ integrated over the ages in each market category) times the average weight in each size category: small = 49 lb, medium = 75 lb, large = 149 lb.

**Calculated by multiplying a price index for each market category times the percent of landings in that market category. The price indexes are:

Pups:	$1.55/$1.80 = 0.8611
Small:	$1.80/$1.80 = 1 (numeraire)
Medium:	$2.05/$1.80 = 1.1389
Large:	$2.30/$1.80 = 1.2778

Table 8-51 . Percent of total U.S. swordfish consumption from imported swordfish. (Source: U.S. Department of Commerce, Fishery Statistics of the U.S.)

	Quantity (million pounds)	Value (million dollars)	Percent of Total U.S. Swordfish Consumption (lb) (Remainder is domestic production)
1960	7.3	3.0	88.0
1965	7.2	3.8	73.0
1968	7.3	4.7	92.0
1969	7.4	5.0	95.0
1970	8.8	5.0	94.0
1971	0.2	0.9	67.0
1972	0.1	0.1	17.0
1973	0.4	0.3	31.0
	(thousand pounds)	(thousand dollars)	
1974	88	37	2.0
1975	26	17	1.0
1976	72	56	2.0
1977			
1978			
1979*	347	492	
1980*	478	632	

*From: Imports and Exports of Fishery Products, Annual Summary 1980, NMFS, NOAA.

In July 1979, Canada reopened the fishery for swordfish. The Canadian swordfishery is currently operating under a quota of 3,000 MT. Canada has a very limited domestic market for swordfish and traditionally the major amount of Canadian caught swordfish has found its way to the U.S. market. Canada plans to issue licenses to foreign vessels to enter Canadian waters to purchase swordfish.

During 1979, Canadian officials met with the U.S. Food and Drug Administration to discuss a proposed program to certify lots of swordfish as to their mercury content for entry into the United States. The certification program was expected to proceed under an interim agreement for purposes of testing the concept with the understanding that a more formal source country certification program could be adopted after more data were accumulated (Food Chemical News, 1979).

8.5.2 Recreational and Subsistence Fisheries

Although detailed economic data on investments, revenues and tourism associated with the recreational sector of the swordfishery are not presently available, there is some information on expenses associated with recreational swordfish activities. Individuals involved in the recreational sector estimate that direct expenses for an overnight swordfishing trip in a private vessel are approximately $200 to $800 depending on geographic area and proximity to fishing grounds. These estimates include expendable gear, bait, gas and food. The price of a chartered swordfishing trip is usually about $750 to $1,000; rod and reel setups, suitable for swordfish, cost from $400 to $450 (J. M. Dorn, John's Rod and Reel, Charleston, S.C.; pers. comm.).

8.6 Description of Businesses, Markets and Organizations Associated with the Fishery

8.6.1 Relationship Among Harvesting, Brokering and Processor Sections

Swordfish catches are sold primarily to brokers, often according to an informal verbal agreement. The fish are dressed on board the fishing vessel, scrubbed down and stored in ice. The dressed weight is about 75 percent* of the total weight (S. Berkeley, Research Associate, University of Miami, Miami, FL; pers. comm.). The dressed fish are unloaded from the fishing vessel and transferred to the broker at the dock. The price per pound, paid by the broker, is calculated for each individual fish and varies with size; larger fish command higher per pound prices. (See Table 8-32 for a description of class sizes.)

A large portion of the swordfish bought by brokers is shipped to the principal fish markets in Boston and New Bedford, Massachusetts; Philadelphia, Pennsylvania; Baltimore, Maryland; and to the Fulton Fish Market in New York City for processing and distribution. The major wholesale markets supply the product to buyers nationwide. The product may be distributed either fresh or frozen.

Some swordfish is sold locally by the brokers to other wholesalers, retail fish markets, supermarkets and restaurants. Some fishermen also sell their swordfish catches directly to the same types of customers.

The following summary of marketing areas resulted from interviews with industry representatives during April 1980 (McAvoy, 1980):

Boston

Boston is the major swordfish distribution center by a wide margin, handling over 4 million lb on an annual basis and more or less sets the market price throughout the country. Swordfish from Florida arrive by truck and air (air shipments arrive in 3,000 lb LD3 refrigerated containers). Southern shipments of swordfish allow wholesalers an opportunity to market swordfish more months of the year. This market buys outright, and not on consignment.

*Dressed weight = 0.75 total weight
Edible weight = 0.8-0.9 (dressed weight)
= 0.60-0.68 (total weight)

Product form on the Boston market is whole fish, head, tail and fins removed and eviscerated. Wholesale price by size class was: (a) 100 lb + = \$3.30 - \$3.40 per lb; (2) 50-100 lb = \$3.10 per lb; 25-50 lb = approximately \$2.90 - \$3.00 per lb; and (3) less than 25 lb, not very acceptable on the market. The premium size range is 90-200 lb. Market price is usually at a low in the summer and during 1979 the low was \$1.50 -\$1.80 per lb.

New York Fulton Fish Market

This market moved approximately 1.1 million lb of fresh swordfish in 1979 (NMFS Market News Office, NY). Florida accounted for 75 percent (850,000 lb), Massachusetts 20 percent (231,000 lb) and NC, ME, RI, VA, and NJ each accounting for a few thousand lb. Only negligible amounts of foreign swordfish have been sold over the Fulton Market since the height of the mercury controversy. In addition, price and quantity information is difficult to ascertain due to the mercury problem.

Product form is the same as that in the Boston Market but with the following size categories: (1) large = 100 lb +; (2) medium = 80-100 lb and (3) small = 50-75 lb. Wholesale prices are vague but the following are estimates: (1) large = \$3.30 - \$3.40 per lb; (2) medium = \$3.15 - \$3.25 per lb; and (3) small = \$2.75 per lb. Pups (less than 50 lb) are hard to move and the dealers require a good size mix.

Atlanta

No fresh, whole, swordfish are being shipped into the Atlanta market.

Chicago

Swordfish is not a major market item in Chicago, perhaps 1,000 lb per week. Most is sold to restaurants with very little going to supermarkets. Product form is the same, whole, head, tail and fins removed and eviscerated.

San Diego

Approximately 250,000-300,000 lb of swordfish move through the market on an annual basis with local fishermen supplying about 90 percent. Companies buy outright, not on consignment. In addition, some companies import directly and also buy through brokers. Some Florida swordfish supply this market.

The bulk of sales are to restaurants and supermarkets in the metro-San Diego area; some fish are sold to Los Angeles distributors and directly to hotels and restaurants in Las Vegas and Phoenix. Local fishermen many times sell directly to these markets in Las Vegas and Phoenix and often land their catches in Los Angeles.

Local catches are greatest during July-October and taper off sharply after November 1. Mexican, Hawaiian and Florida fish make it possible to market swordfish in the spring, fall and early winter months. There is a real or perceived problem with the quality of Florida and Gulf of Mexico fish. Problems cited included soft, discolored and poorly cleaned fish from Florida and improper icing by Gulf fishermen. The result is a shorter storage life for Florida fish and on occasions in the past, Florida fish have sold at a discount. This view was opposed by a Florida broker who regularly ships fish to the West Coast; however, it was agreed that some fishermen must increase their at-sea handling practices during the hot summer months.

TWA, Eastern, Delta and National will ship Florida swordfish to the West Coast in 3,000 lb LD3 refrigerated containers. Market form is the same with the following size categories: (1) 200 lb +; (2) 100-200 lb; and (3) under 100 lb. Very small fish are sharply discounted due to their low yield. Price is the same for medium and large fish, while small fish bring about 10-15¢ less per lb. The current price is between $3.00 and $3.25 per lb; the high price in 1979 was $4.00 per lb, a low of $1.90 per lb and an average of $3.00 - $3.25 per lb.

Los Angeles-San Pedro

In a normal year, about 1 million lb move through this market. Local harpooners are the main source, although increasing amounts are being shipped in from Texas and Florida. Local quality is reported to be greater than shipped-in product due to improper icing and handling.

Several dealers could handle several LD3 container loads per week. Dealers want fish over 100 lb and pay one price (about $3.25-$3.50 per lb) for the mixed bag; however, if too many small fish are in the shipment the entire shipment could be rejected. The low price in 1979 was $1.80-$1.90 per lb.

San Francisco

A conservative estimate of the annual product moved through the market is 300,000 lb. Local catches are very small and as a result most comes from southern California and other parts of the country including Florida.

TWA, Delta, EAL and National will ship Florida fish in LD3 containers. Prices are roughly the same as Boston prices and dealers buy outright.

Seattle

Swordfish is not an important market item.

8.6.2 Fishery Cooperatives or Associations

8.6.2.1 Associations and Organizations

The American Swordfish Association, founded in 1976, is composed of commercial dealers, processors and fishermen on the Eastern and Gulf coasts. The Association is concerned with legal issues as they affect the swordfish industry, and is actively involved in focusing the attention of legislators on problems and issues which affect commercial fishermen. The American Swordfish Association raised money from its members to pay the legal fees incurred in the Anderson Seafoods, Inc. vs. FDA and FDA vs. Anderson Seafoods cases which resulted in raising the action level of mercury in swordfish.

Organized Fishermen of Florida (OFF) was formed in 1967 as a statewide nonprofit trade association devoted to promoting and protecting the interests of Florida fishermen. OFF is made up of individual fresh and salt water chapters. The organization works with the Florida legislature to promote enactment of laws to protect the fishing resources of Florida for both commercial and sports interests, promotes industrywide research on problems facing the industry, provides publicity and public relations programs, and promotes sales and marketing programs.

The National Fisheries Institute founded in 1945 is a trade association with approximately 950 member companies including producers, distributors, wholesalers, importers and canners of fish and shellfish. The Institute disseminates statistics and information of interest to the seafood industry and sponsors market extension and promotion programs on fish and seafood products.

The Southeastern Fisheries Assocation, located in Tallahassee, Florida consists of producers, distributors and suppliers of seafood in the South Atlantic and Gulf of Mexico area.

The Sport Fishing Institute, located in Washington, D.C., promotes the conservation of sport fish and is supported by manufacturers of fishing tackle, outboard motors, boats, sporting goods, petroleum and other related products. The Institute provides research grants, publishes reviews of sport fish conservation activities and conducts educational and informational programs on fisheries science and sport fisheries management.

The Sport Fishery Research Foundation, located in Washington, D.C., has the objective of financially supporting research in the sport fishery resources field.

The International Game Fish Association in Fort Lauderdale, Florida, has more than 10,000 members. The Association supports programs to encourage and further the study of marine game fish angling; analyzes the impact of sports fishing and commercial fishing upon various game fish species; develops and supports game fish tagging and other efforts to collect scientific data; and compiles a worldwide history of marine game fishing. Bimonthly, the Association publishes The International Marine Angler, which disseminates information concerning scientific research on commercial and game fish and reports on angling activities of interest to its members. As of late 1979, the Association is conducting a worldwide survey to tabulate the total amount of swordfish taken on rod and reel prior to initiation of night fishing techniques.

National Coalition for Marine Conservation has as its goals the protection of the marine environment and the development of effective management programs for fishery resources, which enable both commercial and recreational groups to make the best use of marine resources.

There are a number of active sport fishing clubs along the Atlantic and Gulf coasts, the members of which participate in the sport fishery for swordfish and other billfishes. These clubs promote sport fishing in their area, and several sponsor billfish tournaments. In addition, many clubs sponsor tag and release programs and the furtherance of scientific research of big game sport species, through both tournament and regular fishing activities.

Scientists were present at the First, Second, and Third Annual Miami Swordfish Tournaments; First and Second Ft. Lauderdale International Swordfish Tournaments; First, Second and Third Duck Key Tournaments; First, Second and Third Ft. Lauderdale Swordfish Tournaments; and the First and only Stuart Swordfish Release Tournament, to examine the catches. These and other tournaments have provided the scientific community with valuable information regarding the biology of swordfish.

8.6.2.2 Fishery Cooperatives

In 1977, there were 44 fishery cooperatives on the Atlantic Coast and Gulf of Mexico (NMFS). At least a few of these cooperatives, those located mainly in New England and in Florida, have members who fish for swordfish. Cooperatives engaged in swordfishing activities during 1978 and 1979 include the Point Judith Cooperative in Point Judith, Rhode Island; the Provincetown Fisherman's Cooperative in Provincetown, Massachusetts; and the Fort Pierce Cooperative in Florida.

Napoli (1973), in a report on the Workshop on Fisheries Cooperatives held in Galilee, Rhode Island, in 1972, discussed the formation and operation of fishery cooperatives. One of the oldest of the cooperatives is the Point Judith Fishermen's Cooperative Association founded in 1947. The Point Judith Cooperative, because of its early beginnings, has served as an organizational model for the establishment of other fishery cooperatives. The cooperatives generally perform a number of functions for their members, including marketing, supply, production and bargaining. Some, but not all, cooperatives hold marketing agreements with their members which provide for compulsory delivery to the cooperative of all fish caught by the co-op members. Profits earned by the cooperative are distributed to the members on the basis of gross landings of each member in proportion to total landings (Napoli, 1973).

8.6.3 Labor Organizations

Most employees engaged in the commercial fishing industry are covered by the Fair Labor Standards Act, which provides for minimum wages and maximum hours (University of Mississippi Law Center, 1976). However, employees are exempt from these provisions when they are engaged in certain types of offshore fishing activities, namely, during the catching or taking of aquatic forms of animal life; in the first processing when done while at sea; and during the loading and unloading of the aquatic life so taken and processed. The exemption from the Act also applies to employees whose activities are essential to any of the aforementioned activities.

Fishermen in certain New England ports are represented by labor unions, although not all the fishermen in union ports belong to the unions. The use of union crews tends to be more common on company-owned fishing boats. Most swordfishing is done by independently owned or family-owned boats, and it is estimated that only a few, if any, swordfish boats carry union crews. Table 8-52 lists the labor characteristics of the major New England ports with a swordfishing industry. Fishermen in Boston, New Bedford and Gloucester, Massachusetts, are represented by the Atlantic Fisherman's Union and the New Bedford Fishermen's Union, locals of the Seafarers International Union of North America, Atlantic, Gulf, Lakes and Inland Waters District, AFL-CIO. The Unions represent the captain, cook, and deck hands in all negotiations with boat owners. The contracts state conditions under which the men will work, duties, benefits and method of pay. Outside of New England, there is very little union activity.

Workers in seafood processing plants in Boston and New Bedford belong to the Seafood Workers Union, ILA, AFL-CIO (Smith and Peterson, 1977). As a result, wages for these employees have been standardized in these ports.

8.6.4 Foreign Investment

No information is available on foreign investments. However, Booz et al. (1980) conducted interviews and reported that no significant foreign investment is involved in this fishery.

Table 8-52. Labor representation of offshore fishermen in New England ports. (Source: Smith and Peterson, 1977.)

Ports	Labor Representation
Massachusetts	
Boston	Union & nonunion
Gloucester	Union & nonunion
Menemsha	No union or co-op
New Bedford	Union
Provincetown	Co-op & nonunion
Rhode Island	
Newport	Union & nonunion
Point Judith	Co-op
Maine	
Portland	No union or co-op
Rockland	No union or co-op

8.7 Description of Social and Cultural Framework of Domestic Fishermen and Their Communities*

8.7.1 Ethnic Character, Family Structure, Community Organization, Age and Education of Fishermen

There are no data available on ethnic character, family structure and community organization of swordfish fishermen as a separate group. However, Smith and Peterson (1977) have compiled data on labor characteristics of offshore fishermen in major New England fishing ports. Ethnic background and approximate age of offshore fishermen in New England ports with a swordfish fishery as shown by Smith and Peterson are given in Table 8-53. Ethnic characteristics of fishermen vary widely from port to port probably reflecting the ethnic makeup of the overall population in each area. Evidence from interviews indicates that fishermen who participate in the swordfish fishery are not distinctly different from other types of fishermen. Therefore, it can be expected that ethnic character, family structure, community organization, age and education profiles of swordfish fishermen will vary according to area and will reflect characteristics of the general fishing population in each particular area.

8.7.2 Recreational Fishery

From the survey of the recreational billfish and shark fisheries, May 1, 1977 to April 30, 1978, National Marine Fisheries Service estimated that there are from 17,373 to 21,980 boats in the billfish fishery. Based on these data and assuming an average of 3 to 4 anglers per boat for estimation purposes, there may be from around 50,000 to 85,000 participants in the billfish fishery. The proportion of this population that engages in swordfish sport fishing activities cannot, however, be estimated.

There are no data currently available which describe characteristics of participants in the billfish or sport swordfish fisheries. However, information about socio-economic characteristics of the general marine recreational fishing population is available on a state-by-state basis from the 1975 U.S. Fish and Wildlife Survey (Table 8-54). On the Eastern seaboard, saltwater fishing is an activity dominated by males in their middle years with incomes in the $7,500 to $35,000 range.

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*See Holt (1978) for a socio-economic discussion of the California swordfish harpoon fishery.

Table 8-53. Labor force characteristics of offshore fishermen in New England ports with a swordfish fishery. (Source: Smith and Peterson, 1977.)

PORTS	NUMBER OF FULL-TIME FISHERMEN	AVERAGE AGE	MAJOR ETHNIC GROUPS
MASSACHUSETTS			
Boston	100	55	Yankee, Portuguese
Chatham	60-80	45	Yankee
Gloucester	500	45	Italian, Yankee
Menemsha	30	40	Yankee
New Bedford	400	43	Yankee, Norwegian Canadian, Portuguese
Provincetown	150-200	40	Yankee
RHODE ISLAND			
Newport	80	45	Yankee, Portuguese Italian
Pt. Judith	120	40	Yankee, Norwegian
MAINE			
Portland	150	40	Yankee
Rockland	80	40	Yankee

Table 8-54. Socio-economic characteristics of saltwater recreational participants by state of residence, 1975. (Source: U.S. Department of the Interior, 1977.)

	State of Residence															
	AL	FL	GA	LA	MS	NC	SC	TX	DE	ME	MD	MA	NH	NJ	NY	RI
Number of Participants (000)	239	1740	471	575	192	865	311	2010	114	98	509	601	66	889	1212	100
Age	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
9-17	19	18	32	21	23	15	15	22	25	26	15	19	10	29	13	26
18-24	25	11	18	12	10	12	23	10	12	13	14	17	14	11	11	16
25-34	17	28	13	26	22	30	30	23	23	22	13	27	36	20	25	18
35-44	19	13	11	11	25	14	14	8	13	10	25	10	10	12	16	15
45-54	3	8	16	18	8	20	12	18	13	15	17	17	14	16	20	9
55-64	12	13	9	12	5	5	4	8	10	12	11	8	9	3	3	10
65 or older	5	9	1	-	7	4	2	8	4	2	5	1	5	3	7	6
Sex																
Male	66	73	74	70	70	72	73	73	72	69	80	86	78	81	81	86
Female	34	27	26	30	30	28	27	27	28	31	20	14	22	19	19	14
Income																
Under $2,000	15	7	14	16	19	11	7	8	12	15	11	9	8	13	16	10
$2,000 - $4,999	7	6	4	3	2	6	8	9	*	3	*	8	5	8	3	7
$5,000 - $7,499	7	5	3	3	4	8	3	7	7	10	4	9	8	7	3	5
$7,500 - $9,999	6	21	5	5	10	16	8	15	6	18	*	5	11	8	5	11
$10,000-$14,999	18	22	13	17	17	21	32	12	30	28	29	33	29	22	16	25
$15,000-$24,999	38	26	31	35	22	26	29	21	34	22	37	27	26	32	38	31
$25,000-$34,999	9	12	9	8	19	9	5	23	8	2	12	9	11	6	8	6
$35,000-$49,000	-	1	15	4	2	1	6	2	2	*	2	*	4	2	7	2
$50,000 or more	*	*	6	9	5	2	2	3	*	*	*	*	2	3	2	1

*Less than one percent

Since swordfishing grounds are 70 to 100 miles offshore along a good deal of the Atlantic Coast, the costs for swordfishing tend to be greater than for many other species. Thus, it can be expected that income levels of sport swordfishermen may in general be somewhat higher than the average for all marine fishing participants.

Social benefits of recreational fishing have been reported to include "escape" from the pressures of modern civilization, the chance to be outdoors, to be with friends or family and to have fun (Martin, 1976). In a study of charter boat fishermen in Texas, Ditton et al. (1978) identified fishing motives and ranked them in relative order of importance using mean factor importance scores rated on a six point scale from 1 = not at all important, to 6 = extremely important. Some findings from their study are given in Table 8-55. Having fun, escaping normal routines, adventure, being with others and learning about nature were ranked high. Ditton et al. (1978) reported that the quality aspects of catch, i.e., excitement, unique experience, challenge and adventure, were considered more important than just the quantity of fish caught.

8.7.3 Economic Dependence on Commercial or Marine Recreational Fishery and Related Activities

There are no data currently available concerning economic dependence on commercial or marine recreational fishing and related activities for the swordfish fishery. However, it is known that a number of vessels are involved in the year-round fishery for swordfish. These include a number of vessels from the mobile northern longline fleet as well as vessels in the local southeastern Florida fishery. It is estimated that there are approximately 50 mobile longline vessels which fish up and down the Atlantic Coast and in the Gulf of Mexico, fishing in the warmer waters during winter months, and northern waters in summer months. There are approximately 25-28 northern harpoon vessels and approximately 22 spotter airplanes. There are also approximately 150-200 full-time vessels in the fixed base Florida fishery and 50-100 boats in the expanding Gulf of Mexico fleet. Thus it can be expected that there are approximately 1,000* fishermen who derive most if not all their income from swordfishing activities. In addition, some fishermen who fish for swordfish during only part of the year report that because of the high economic value of swordfish, swordfishing activities account for a major part of their total fishing revenues.

*Based on a crew of at least 3 in Florida longline boats, 4-5 in New England longline and harpoon boats and 22 pilots flying spotter airplanes.

Table 8-55. Motivational factors in recreational fishing. (Source: Ditton et al., 1978)

Motive	Mean Factor Importance [a]
Have fun	5.14
Escape	3.75
Adventure experience	3.54
Affiliation	3.42
Learn about nature	3.34
Catch fish	3.29
Outdoor coastal experience	3.21
Fishing challenge	3.17
Convenience in fishing	3.12
To eat fish	2.81
Personal achievement	2.11
Establish and maintain business relationships	2.09
Status achievement	1.68

a. Derived on a six point rating scale from 1 = not at all important, to 6 = extremely important.