

## The Purse-Seine Fishery for Bluefin Tuna in the Northwestern Atlantic Ocean

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**ABSTRACT**—The history of the purse-seine fishery for bluefin tuna in the northwestern Atlantic Ocean is reviewed, and events that contributed to fluctuation of the catch are discussed. The fishery began in 1958 and produced 5,770 mt (metric tons) at its peak in 1963. The catch declined from 4,290 mt in 1970 to about 1,780 mt in 1973. The 1973 catch was landed by a fleet with about 4,900 mt carrying capacity, which was in excess of the catch. Average length of bluefin tuna in the purse-seine catch decreased from about 140 cm in 1960 to about 89 cm in 1973, owing in part to a southward expansion of the fishing grounds into areas where small bluefin tuna are more available. Prior to 1962, the fishing grounds were centered in Cape Cod Bay. Currently it is centered off New Jersey-New York. The nominal catch rate of Class 3 seiners has fluctuated, but it appears that the prevailing trend in the 1970's is downward with the current rate at a low level.

### INTRODUCTION

The northern bluefin tuna (*Thunnus thynnus thynnus*) was considered a nuisance by U.S. fishermen of the Atlantic coast until at about the turn of this century a domestic market was developed, first for the oil then only for the meat (Bigelow and Schroeder, 1953). Traps, harpoons, and handlines were the primary gear used to catch bluefin tuna in the northwestern Atlantic before 1958. The total Canada-U.S. catch averaged about 900 tons<sup>1</sup> annually in 1942-57. In 1958, purse-seine fishing was introduced (Squire, 1959; Wilson, 1965), and the total catch (all gear) increased to an average of 2,800 tons annually (Fig. 1), but the catch has fluctuated considerably. In fact, the total catch since 1969 declined from 4,800 tons in 1970 to 2,400 tons in 1972. This report reviews the development of the purse-seine fishery for bluefin tuna in the

northwestern Atlantic and describes some events that had a bearing on fluctuation of the catch.

### THE FISHERY

Canada and the United States are the only participants in the purse-seine fishery for bluefin tuna in the northwestern Atlantic Ocean. As early as 1937 purse seines were experimentally used to catch bluefin tuna in the northwestern Atlantic (Murray, 1952).

Purse seining by commercial fishermen and trolling by recreational fishermen for bluefin tuna off the east coast of the United States. U.S. commercial and recreational fishermen compete for bluefin tuna during the summer and fall months offshore from New Jersey to Maine.

However, the fishery, as we know it today, essentially began in 1958 when the *Silver Mink*, a 41-ton carrying capacity U.S. purse seiner, demonstrated in Cape Cod Bay, Mass. that bluefin tuna could be caught commercially (Squire, 1959; Wilson, 1965). From 1958 to about 1962 only small, U.S. seiners (<92 tons carrying capacity), based in New England ports, participated in the fishery, which was centered in Cape Cod Bay. In 1962, the fishery expanded southward as far as North Carolina (Wilson, 1965). In 1963, Canadian seiners (100 tons capacity) and large, California- and Puerto Rico-based seiners (>363 tons capacity) entered the fishery. These

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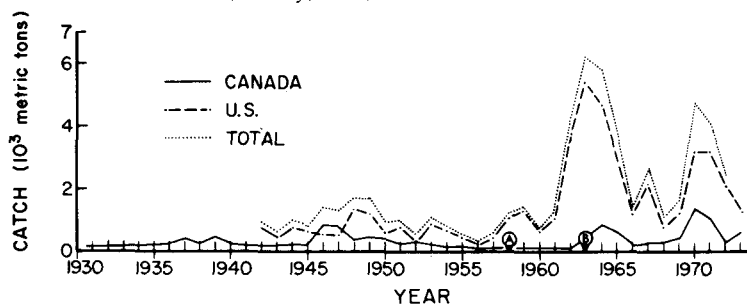


Figure 1.—Canadian and U.S. commercial catch of bluefin tuna from the Atlantic Ocean: A, the year 1958 when the purse-seine fishery first started; B, the year 1963 when large seiners (>181 tons capacity) first entered the fishery. The 1973 catches are preliminary and only includes purse-seine catches.

<sup>1</sup>Tons refer to metric tons in this report.

events transformed the fishery into one with cosmopolitan participation with vessels fishing for bluefin tuna as well as the tropical tunas, yellowfin (*T. albacares*) and skipjack (*Katsuwonus pelamis*), that occur in fishable quantities in some years off the east coast of the United States (Wilson, 1965).

Unlike the trap, harpoon, and hand-line fisheries that generally catch large bluefin tuna (>122 cm long<sup>2</sup>), the purse-seine fishery primarily catches schooled bluefin tuna, 50-122 cm long, which are sold to canneries for processing into canned tuna. Fish larger than about 140 cm long are generally undesirable for canning and are sold to fresh-fish markets. (Currently, Japan is an important market for the large fish.) In any one year, not more than about 16 percent of the purse-seine catch, in weight, has been large bluefin tuna.

The purse-seine fishery operates within a narrow belt that extends about 220 km from the coast. Fishermen claim that not many schools are found beyond that region. Mather and Schuck<sup>3</sup> indicated that schooled bluefin tuna are found in the northwestern Atlantic between Cape Charles, Va. and Newfoundland, but primarily between Cape Charles and Cape Cod, Mass.

Through the years the use of land-based aircraft to assist seine fishermen in locating and setting on schools of bluefin tuna has become popular. Virtually all the small seiners and some large seiners currently use aircraft in fishing operations. The technique is quite effective in that it increases the searching range and fishing success of the vessels. This is probably a major factor contributing to the ability of the small vessels to consistently catch a large share of bluefin tuna from the northwestern Atlantic (Sakagawa and Coan<sup>4</sup>).

<sup>2</sup>Length measurements are straight line distances from tip of snout to fork of tail.

<sup>3</sup>Mather, F. J. III, and H. A. Schuck. Contribution to the biology of the bluefin tuna (*Thunnus thynnus*) of the western North Atlantic. Part I. Age and growth, distribution, and migrations. Manuscript, 177 p. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.

<sup>4</sup>Sakagawa, G. T., and A. L. Coan. A review of some aspects of the bluefin tuna (*Thunnus thynnus thynnus*) fisheries of the Atlantic Ocean. Manuscript, 83 p. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California 92037.

## TOTAL CATCH

The total Canadian-U.S. landings (all gear) of bluefin tuna from the northwest Atlantic historically fluctuated around 900 tons annually until 3 years after the purse-seine fishery became established in 1958 (Fig. 1). The total landings then increased sharply from 1,200 tons in 1961 to

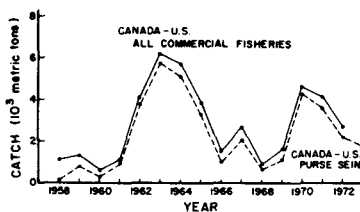


Figure 2.—Total Canada-U.S. commercial catch of Atlantic bluefin tuna by the purse-seine fishery.

Figure 3.—Percent distribution of catch of bluefin tuna and fishing effort for purse seiners participating in the bluefin tuna fishery of the northwestern Atlantic.

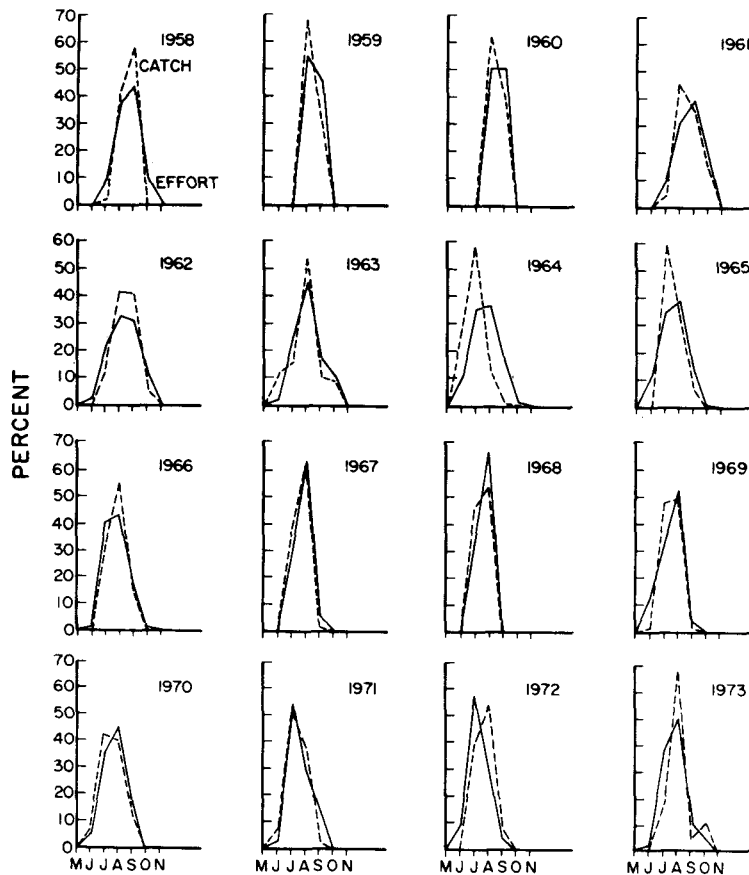


Table 1.—Purse-seine catches (Canadian and U.S. combined) of bluefin and skipjack tuna in the northwestern Atlantic Ocean, 1958-73.

Year	Number of seiners	Catch (metric tons)		
		Bluefin <sup>1</sup>	Skipjack <sup>2</sup>	Total
1958	1	138	0	138
1959	1	781	0	781
1960	1	277	0	277
1961	2	903	0	903
1962	7	3,767	434	4,201
1963	18	5,770	2,899	8,669
1964	21	5,187	4,974	10,141
1965	13	3,331	179 <sup>3</sup>	3,510
1966	7	1,006	149 <sup>3</sup>	1,155
1967	11	2,083	3	2,086
1968	5	688	23	690
1969	4	1,118	103 <sup>3</sup>	1,221
1970	8	4,287	850 <sup>3</sup>	4,937
1971	12	3,825	610 <sup>3</sup>	4,435
1972	11	2,137	44 <sup>3</sup>	2,181
1973	7	1,781 <sup>4</sup>	35 <sup>4</sup>	1,816 <sup>4</sup>

<sup>1</sup>Sources: Aloncle et al (1972), Fishery Statistics of the United States (1960-69, 1971-73) and Statistics and Market News Division, National Marine Fisheries Service, Washington, DC 20235. Virtually all bluefin tuna are landed in the year caught, and landings are considered catches in this report.

<sup>2</sup>Estimated catch statistics from Mather, F. J. III, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 (pers. commun.) except those from logbooks (see footnote 3).

<sup>3</sup>Estimates from logbooks.

<sup>4</sup>Preliminary estimates.

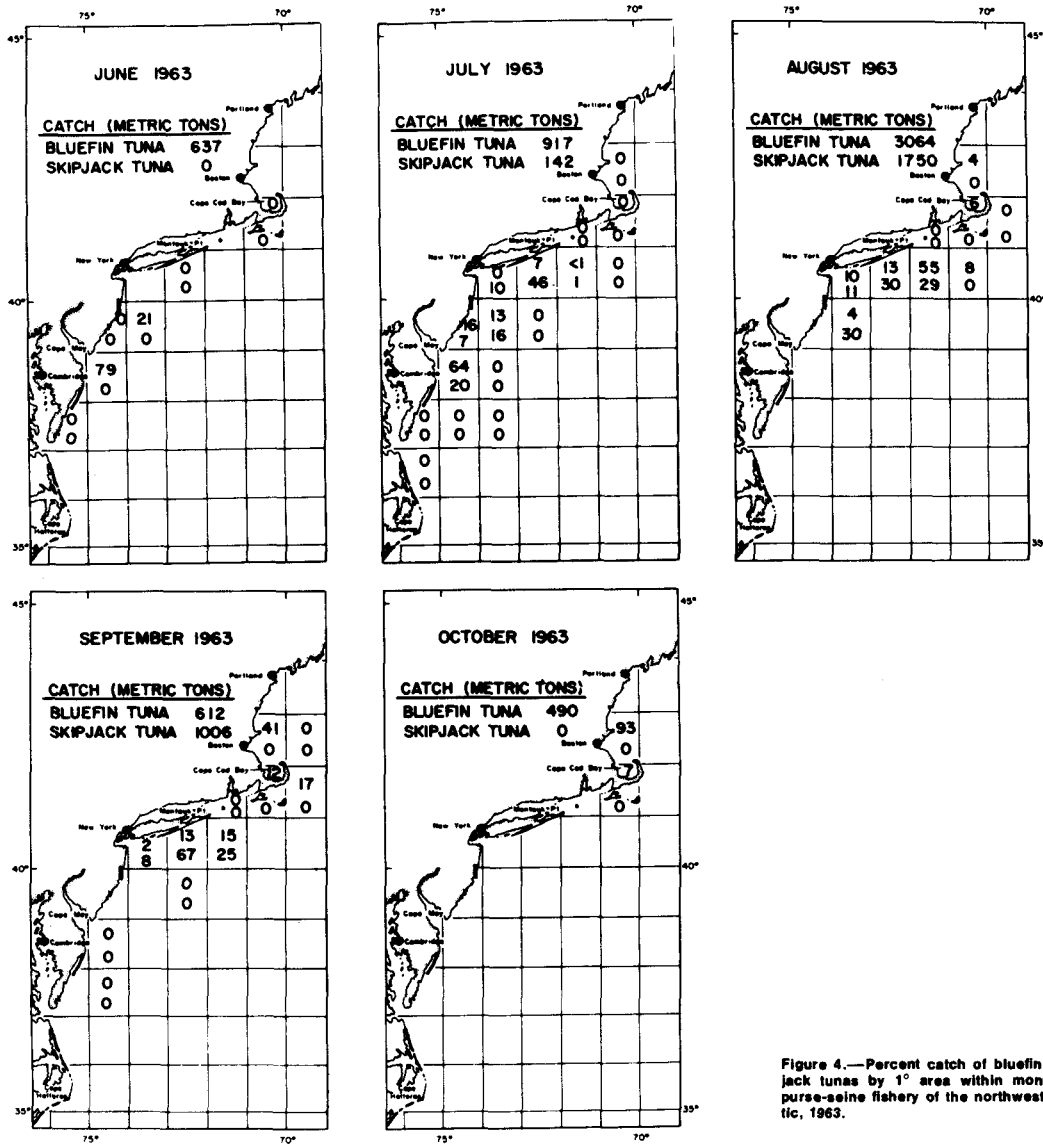


Figure 4.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1963.

6,200 tons in 1963, decreased to 1,100 tons in 1968, increased again to 4,800 tons in 1970, and declined to 2,400 tons in 1972 (Fig. 1).

Since 1960, more than 90 percent of the total annual landings of bluefin tuna made by Canadian and U.S. fishermen has been attributed to the purse-seine fishery. The purse-seine catch of bluefin tuna was 140 tons in 1958; it peaked in 1963 at 5,770 tons, declined substantially in 1968, and rose to another peak of 4,290 tons in 1970 (Fig. 2). The catch then declined to about 1,780 tons in 1973.

Skipjack tuna and small amounts of yellowfin tuna are also caught in the bluefin tuna fishery. The catches of tropical tunas, however, are usually a minor part of the total catch, although in 1964 the skipjack tuna catch of 4,970 tons was nearly equal to the bluefin tuna catch of 5,170 tons (Table 1).

The fishery operates during a short season, June through early October, with virtually all (90 percent or more) of the catch and effort concentrated in July and August (Fig. 3). Weather is believed to be an important determin-

ing factor for the short season. Availability is another. Apparently, changes in migration patterns influence the availability of bluefin tuna to the purse-seine fishery (Mather, Rothschild, Paulik, and Lenarz<sup>5</sup>). Wilson (1965) stated that the purse-seine fishing season was increased by expansion of the fishery into southern fishing grounds, where schooled fish are available earlier in

<sup>5</sup>Mather, F. J. III, B. J. Rothschild, G. J. Paulik, and W. H. Lenarz. Preliminary analysis of bluefin tagging data. Manuscript, 27 p. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California 92037.

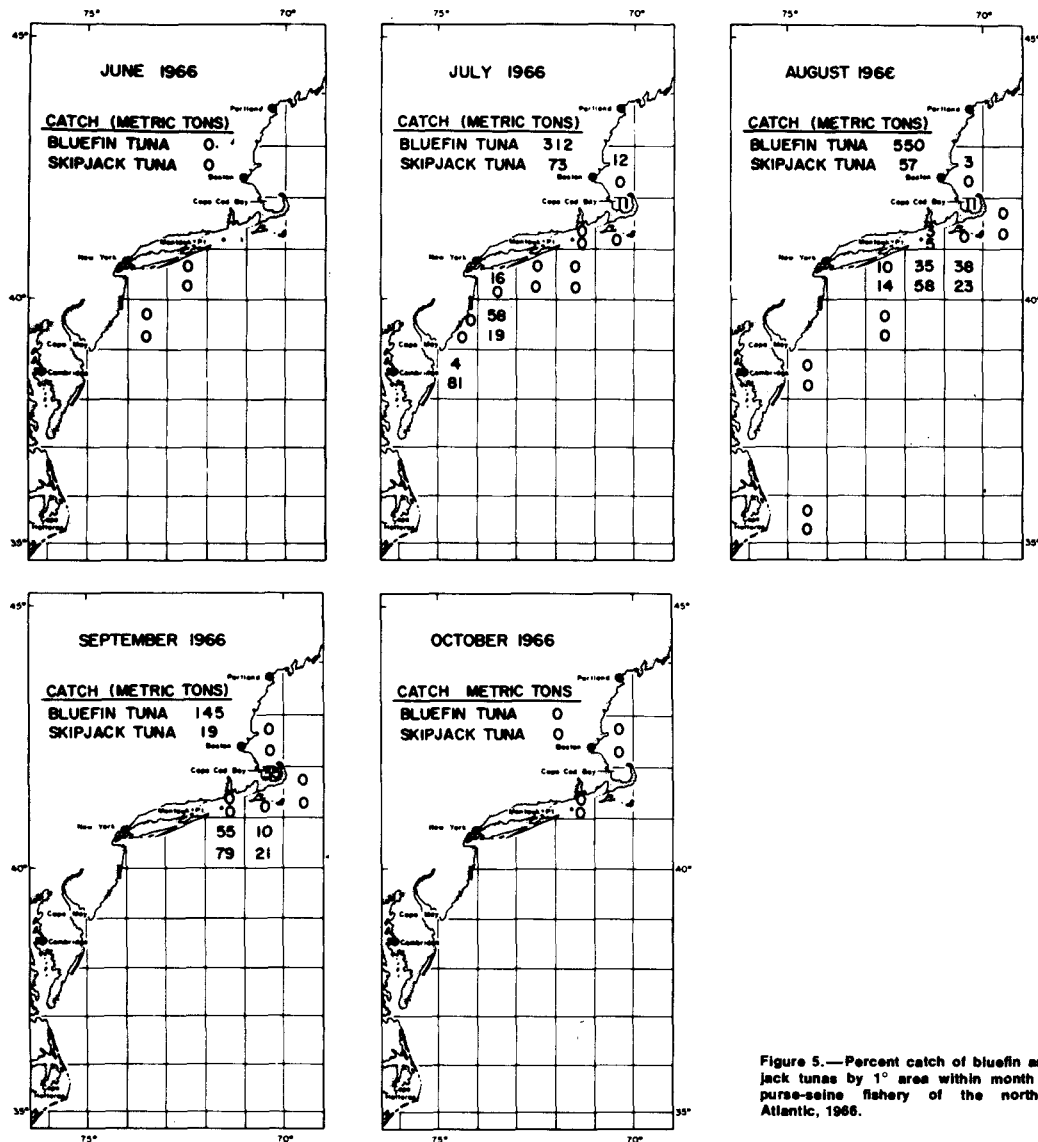


Figure 5.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1966.

the year than in the region north of Cape Cod.

During the early years, the 1950's and early 1960's, of the purse-seine fishery, a greater amount of the season's catch was made in September and October. The fishery during the early years was centered in Cape Cod Bay with little effort expended south of Martha's Vineyard (Wilson, 1965). In 1962, the fishery expanded south of Martha's Vineyard. Currently most of the bluefin tuna are caught in July and August off New Jersey and New York, perhaps before they can travel

northeastward to be available in more northern waters in September or October (Sakagawa and Coan, Footnote 4; Mather et al, Footnote 5). Most current catches in September and October are made in Cape Cod Bay and consist of fish primarily larger than about 122 cm long. Generally, Cape Cod Bay is considered a good fishing ground for large bluefin tuna (Wilson, 1965).

The fishery operates within a small geographic area and the catch is obtained from only a few "key" 1° × 1° areas, those in which 20 percent or

more of the bluefin tuna are caught in any one month. The percent catches in 1° × 1° areas by months for 3 years, 1963, 1966, and 1973 which represent years of peak catch (1963), low catch (1966), and recent catch (1973), are shown in Figures 4, 5, and 6. In June, there is not much fishing and usually only one or two key areas off the New Jersey coast are fished by the purse-seine fleet. In July, schooled bluefin tuna are caught in several key areas off New Jersey and Long Island, N.Y. between lat. 38°N and 41°N. In August and September,

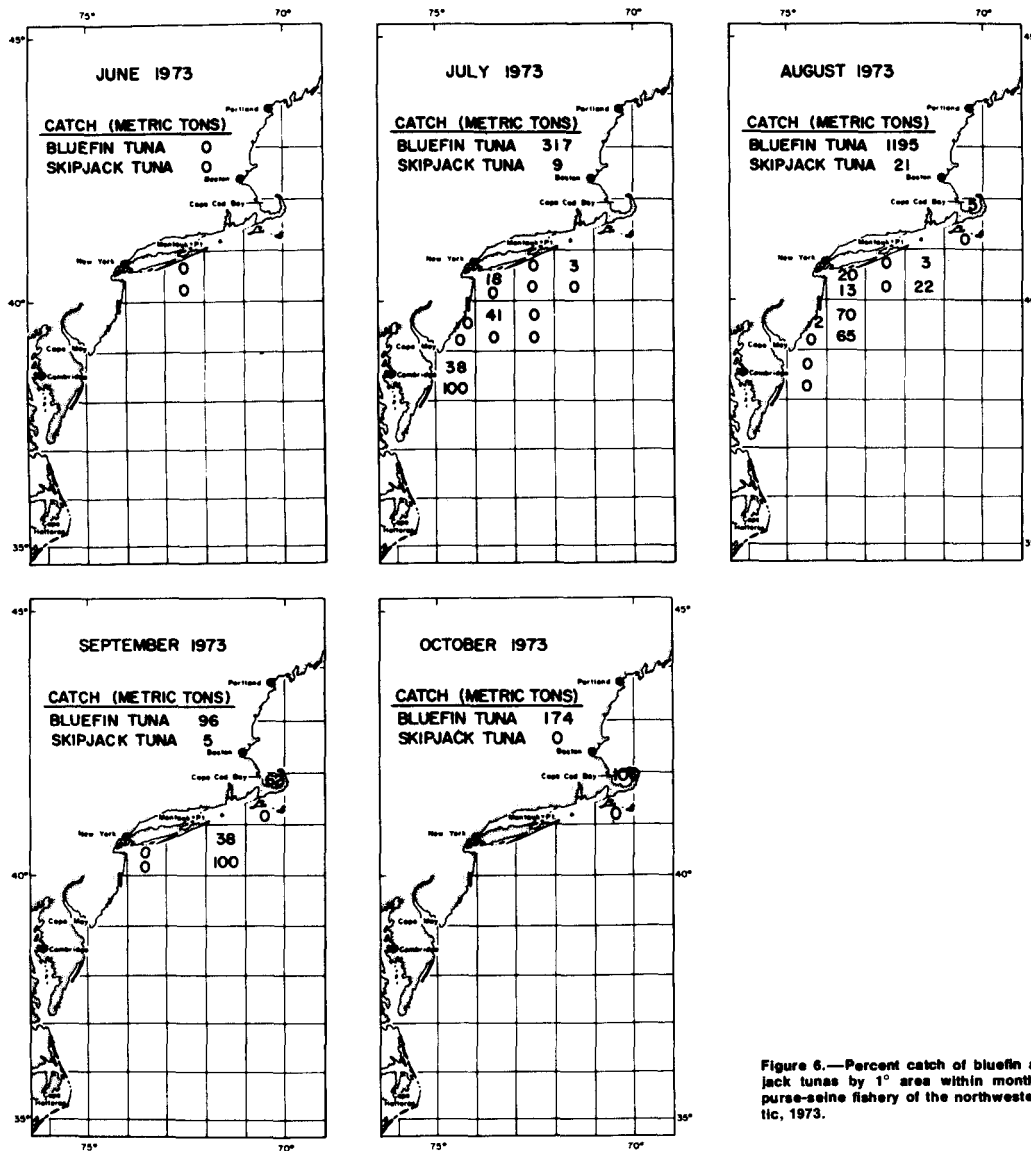


Figure 6.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1973.

the key areas are primarily off Long Island, although in 1963, substantial catches were made in a more northern area, off Boston, Mass. in September. Very little fishing is done in October because of poor weather conditions and availability. Catches during that month generally have been made off Rhode Island and Massachusetts and consist of larger fish (> 122 cm).

#### FISHING EFFORT

The number of vessels in the bluefin tuna purse-seine fishery increased from 1 boat in 1958 to 21 boats in

1964, and thereafter fluctuated between 4 and 13 boats, averaging about 9 boats fishing per year (Table 2). Currently there are two major groups of seiners that participate in the fishery (Table 2). One group is seiners 92-181 tons capacity based primarily in New England ports which fish regularly for bluefin tuna in the northwestern Atlantic. Their trips seldom last more than a week. The second group is of seiners 364-1,000 tons capacity based in California, Puerto Rico, and New Brunswick, which fish irregularly in the north-

western Atlantic for tunas. Usually these large vessels enter the fishery only when tropical tuna fishing in the eastern Pacific or in the eastern Atlantic is poor. They are capable of remaining at sea for several months and usually return to their home ports to unload or for provisions.

Although there was a decrease of 14 boats (67 percent) in the fishery from 1964 to 1973, the carrying capacity of the fleet decreased only by 40 percent; the bluefin tuna catch decreased by 66 percent over the same period. The total carrying capacity of

Table 2.—Numbers and classes of purse seiners participating in the bluefin tuna fishery of the northwestern Atlantic Ocean, 1958-73.<sup>1</sup>

Year	Estimated total carrying capacity <sup>2</sup>	Class (carrying capacity <sup>2</sup> )						Total
		1 (0-45)	2 (46-91)	3 (92-181)	4 (182-272)	5 (273-363)	6 (364+)	
1958	40	1	-	-	-	-	-	1
1959	40	1	-	-	-	-	-	1
1960	40	1	-	-	-	-	-	1
1961	100	1	1	-	-	-	-	2
1962	1,000	1	2	2	1	1	-	7
1963	5,300	1	4	3	4	-	6	18
1964	8,100	1	4	3	2	2	9	21
1965	3,400	1	4	3	1	-	4	13
1966	900	1	2	3	-	-	1	7
1967	5,100	-	1	3	1	-	6	11
1968	700	-	1	3	1	-	-	5
1969	400	-	1	3	-	-	-	4
1970	3,500	-	1	3	-	-	4	8
1971	8,200	-	-	3	1	-	8	12
1972	6,200	-	-	3	1	-	7	11
1973	4,900	-	-	3	-	-	4	7

<sup>1</sup>Data are from the following sources: 1958-63 from Wilson (1965), 1964-73 from Mather F. J. III, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 (pers. commun.) Beckett, J.S., Fisheries Research Board of Canada, St. Andrews, N.B. (pers. commun.) and the Inter-American Tropical Tuna Commission, La Jolla, CA 92037.

<sup>2</sup>Carrying capacity in metric tons.

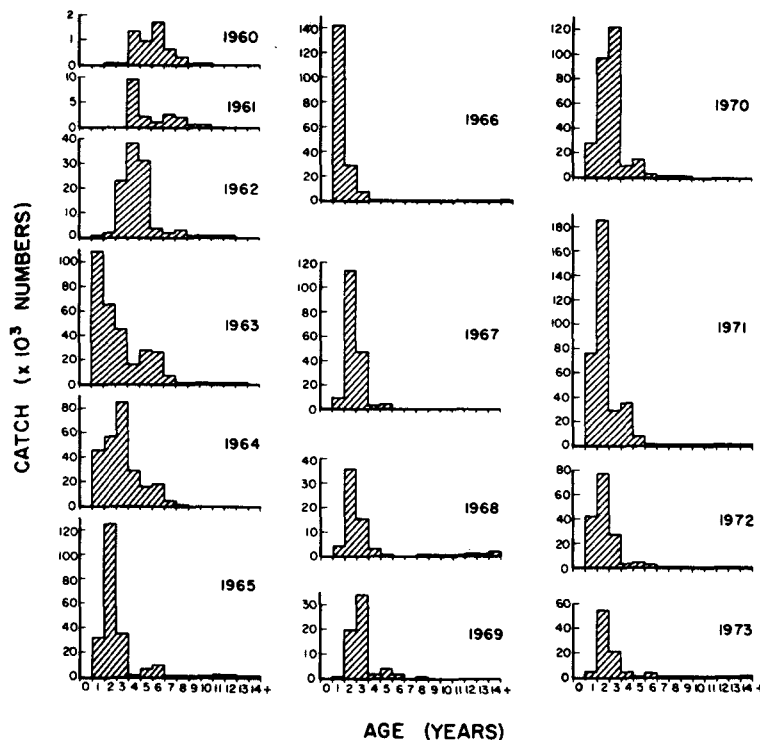


Figure 7.—Age composition of the purse-seine catch of bluefin tuna from the northwestern Atlantic.

the 1973 fleet was excessive in that it was about 4,900 tons, bringing in only 1,780 tons of bluefin tuna. It appears that the recent trend has been for larger but fewer boats in the fishery with a fleet carrying capacity in excess of the catch.

Data on nominal fishing effort in terms of fishing days have been col-

lected from the bluefin tuna purse-seine fleet since the establishment of the fishery in 1958. It has been presented as effective effort (i.e. being proportional to instantaneous fishing mortality) in some published accounts (e.g. Aloncle, Hamre, Rodriguez-Roda, and Tiews, 1972; Lenarz, Jones, and Mather, 1972). Changes within the

fishery, however, such as the entry of large seiners, the increased use of aircraft, and the southward expansion of the fishing grounds, have affected the fishing efficiency of the boats and the nature of the effort statistics collected through the years. For example, a unit of nominal fishing effort of a Class 3 seiner (92-181 tons) is not equal in terms of mortality generated to a unit of nominal fishing effort of a Class 6 seiner (>364 tons), since Class 3 seiners more often use aircraft to aid in searching for schools and use smaller seines than do Class 6 seiners. Furthermore, Class 3 seiners were formerly in the unique position of being able to fish in both deep and shallow waters whereas larger seiners, with deeper nets, were able to fish only in deep water (Wilson, 1965). There has also been a change in the fishing effectiveness of perhaps all boats as the captains and crews became more proficient in the fishing techniques (Wilson, 1965), but particularly in that of Class 3 seiners as they increased their dependence on aircraft to locate schools and to assist in positioning the net. Because of these changes in the efficiency of the vessels, nominal fishing effort for the fleet is not a reliable measure of effective effort from one year to another.

#### AGE COMPOSITION OF CATCH

Sakagawa and Coan (Footnote 4) estimated the age composition of the purse-seine catch for 1960-72. I estimated the composition for the 1973 catch using that method. The results show three phases in the development of the purse-seine fishery (Fig. 7). The first was in 1960-62 when age groups

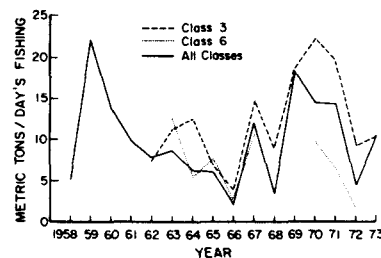


Figure 8.—Nominal catch rates by class of vessel in the purse-seine fishery for bluefin tuna in the northwestern Atlantic.

3-6 years dominated the catch. A transition phase followed in 1963 and 1964 when the catch was dominated by a combination of younger fish as well as 3-year old to 6-year old fish. The last phase began in 1965 when the young age groups (1-3 years) dominated the catch with few older fish represented. In 1973 the average length of bluefin tuna in the catch was 89 cm, whereas it was 140 cm in 1960.

The changes in the age composition of the catch should be recognized as influenced in part by the southward expansion of the fishing grounds. In the early stages of the fishery's development, the fishery was centered north of Cape Cod, where primarily large fish are available (Wilson, 1965). As the fishery expanded southward, beginning in 1962, into areas where younger fish are more available, more smaller fish were caught (Sakagawa and Coan, Footnote 4; Mather et al., Footnote 5). Finally, in the last phase the fishery was centered off New Jersey-New York, where primarily young bluefin tuna are found.

### CATCH RATE

Most published catch rates (CPUE) for the northwestern Atlantic purse-seine fishery for bluefin tuna are based on total days fishing or total nominal effort (Fig. 8). As was stated above, nominal effort is not a reliable measure of effective effort, hence fishing mortality, because of changes, particularly in efficiency, of the vessels over the years. Consequently, the nominal CPUE's in Figure 8 are likewise unreliable for indexing abundance unless change in vessel efficiency is taken into account.

Sakagawa and Coan (Footnote 4) indicated that vessel efficiency, at least for Class 3 vessels, probably has increased since the mid-1960's when vessels began relying more heavily on aircraft to locate schools and cooperating more fully among themselves in fishing operations. In Figure 8, the nominal CPUE's for Class 3 vessels since the mid-1960's are therefore probably overestimated and should be adjusted downward to reflect the increase in vessel efficiency. The CPUE's for the 1970's would then indicate a more pronounced decline than depicted in Figure 8.

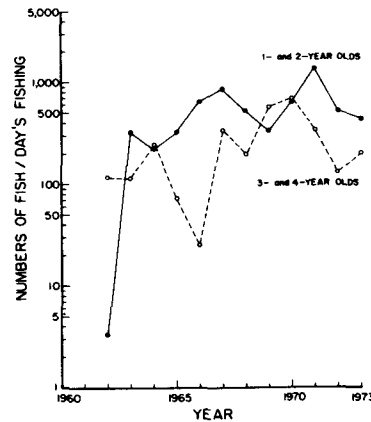


Figure 9.—Nominal catch rates of 1- and 2-year old and 3- and 4-year old bluefin tuna for Class 3 vessels in the purse-seine fishery for bluefin tuna in the northwestern Atlantic.

The CPUE's for Class 3 vessels in terms of numbers of fish are shown in Figure 9. Only CPUE's for age groups 1 and 2 and 3 and 4 are shown. These age groups represent sizes of fish (< 140 cm) that are most sought after by the purse-seine fishermen. The CPUE's have not been adjusted for changes in vessel efficiency. They nevertheless indicate that apparent abundance of age groups 1-4 was at a high level and the CPUE of 3- and 4-year olds was less than that of the recruits, 1- and 2-year-old fish, in most years.

In the 1970's, the general trend of CPUE's for both the recruits and 3- and 4-year olds is downward, although the CPUE of recruits somewhat leveled off and that of 3- and 4-year olds increased in 1973. This declining trend is probably associated with changes in survival and availability of recruits and changes in the abundance of the spawning stock.

### DISCUSSION

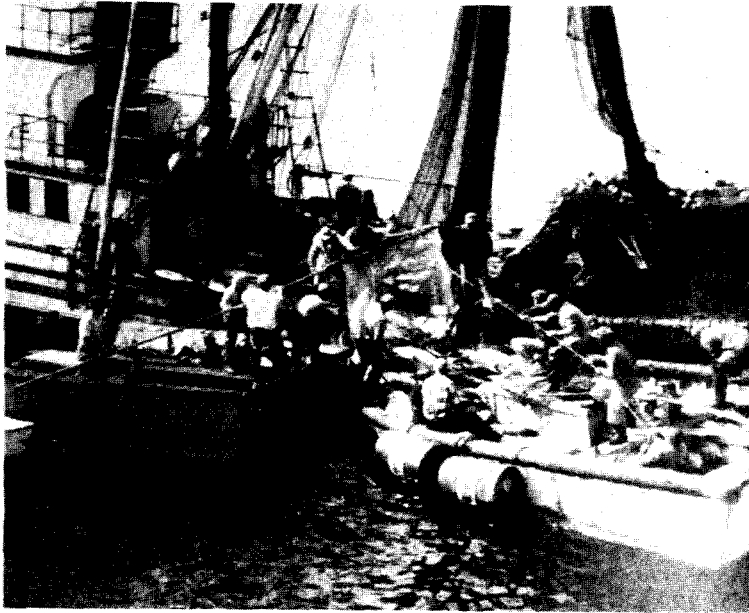
The bluefin tuna catch of the purse-seine fishery of the northwestern Atlantic ranged from 138 tons in 1958, the year the fishery was established, to 5,770 tons in 1964. The most recent catch was 1,781 tons. The fluctuations in catch are possibly due to (1) variation in migration patterns (Mather et al., Footnote 5) and location of the fishery, (2) variation in the amount of effective effort used to bring the catch, (3) variation in recruitment or stock abundance, and (4) variation in fish-

ing effort of the sport fishery, which competes with the seine fishery for bluefin tuna, or a combination of any of these.

Besides the purse-seine and sport fisheries of the northwestern Atlantic, commercial fisheries in the Bay of Biscay, off Portugal, and off northern Africa also catch small Atlantic bluefin tuna (50-122 cm long) during the summer and fall. There is uncertainty as to whether these widely separated fisheries normally exploit fish from separate stocks or from a common stock. Tagging experiments, however, have demonstrated that, at least in some years, fish of similar stocks are exploited in the eastern and western Atlantic (FAO, 1972). Mather, Bartlett, and Beckett (1967), for example, examined tagging data and hypothesized that between the summers of 1965 and 1966 there was sufficient migration of young bluefin tuna from west to east to cause a decline in catch from the northwestern Atlantic and a concomitant increase in catch from the Bay of Biscay. Aloncle<sup>6</sup> concluded from tag returns of small bluefin tuna tagged in the eastern Atlantic that independent American and European stocks exist but that east-west migration does occur. Thus, the degree of transatlantic migration has at least in some years affected the catch from the northwestern Atlantic.

Tagging studies have also demonstrated that in the northwestern Atlantic changes in migration pattern with age of fish affect the availability of different age groups of bluefin tuna to the purse-seine fishery (Mather et al., Footnote 5). Mather et al., (Footnote 5) found that a higher proportion of tagged 1.4-year old bluefin tuna returned to the fishing area off the United States east coast the year after their release than did older fish. Since the age groups represented in the purse-seine catch have varied, availability of the different age groups has probably contributed to the variation in the catch. Of course, superimposed on this effect of variable availability is the effect of variable year-class strength, which would also contribute to variation in catch.

<sup>6</sup>Aloncle, H. Marquage de thons rouges dans le Golfe de Gascogne. Manuscript, 11 p. Institut des Pêches Maritimes, La Noë-Route de la Janelière, 44-Nantes.



Brailing bluefin tuna from a purse seine net off the U.S. east coast.

Trends in the nominal fishing effort for the purse-seine fishery suggests that total effective effort has fluctuated owing to changes in the number, size, and efficiency of vessels in the fleet. The fluctuation, of course, contributed to the variation in the purse-seine catch.

Class 3 nominal catch rates for the 1970's are overestimated relative to those of earlier years because of improved fishing efficiency since the mid-1960's. When improved efficiency is taken into account, a declining trend prevails in the catch rates for the 1970's; the current catch rate is low, perhaps at the lowest level since the establishment of the fishery. Thus,

the catch rates of the 1970's suggest that the stocks fished by the fishery possibly declined in abundance or availability, which has contributed to the recent decline in the purse-seine catch.

Finally, sport fishermen in the northwestern Atlantic compete with seine fishermen for bluefin tuna. Although the total sport catch of schooled bluefin tuna is not known, rough estimates (Sakagawa and Coan, Footnote 4) suggest that the catch was large enough in some years to have an impact on the purse-seine catch.

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