# ASSOCIATIONS OF TUNA WITH FLOTSAM IN THE EASTERN TROPICAL PACIFIC

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ABSTRACT

The fishing record for flotsam-associated tuna in the eastern tropical Pacific was examined. The rivei of Central America are probably the major source of flotsam. Correlation analysis of the number of se occurring in an area indicates that unassociated tuna and flotsam-associated tuna are related. Tl number of sets made on floating objects has increased dramatically since 1971. The percentage flotsam-associated sets has increased, indicating that flotsam-associated sets are more important to the tuna fishery than in 1963. The catch per set of tuna associated with flotsam has also increased markedly since 1967. Analysis of length-frequency data indicate that, on a single set basis, tuna fork length is more variable in sets associated with flotsam than with unassociated schoolfish sets. Results of the length-frequency analysis support the idea that flotsam aggregates tuna.

The catch of the eastern tropical Pacific tuna fishery consists of mostly yellowfin tuna, *Thunnus albacares*, and skipjack tuna, *Katsuwonus pelamis*. The catch is frequently categorized by the conditions under which the purse seine set is made. Scott (1969) made a major distinction between associated schools and unassociated schools. Associated schools are caught either in "porpoise sets" (sets associated with porpoise) or "floating object sets" (sets associated with logs or other flotsam). Unassociated schools are caught in "night sets" (sets made at night with the aid of bioluminescence) and "schoolfish sets" (schools seen and set upon during the day). Night sets compose a very small proportion of total sets and will not be discussed in this paper. Porpoise sets catch mostly yellowfin tuna. Floating object sets and schoolfish sets catch yellowfin and skipjack tuna, either as pure or mixed species.

Little is known about the attraction of tuna to flotsam. Gooding and Magnuson (1967) and Hunter and Mitchell (1968) observed fish gathering around flotsam. These authors attracted some tuna to their flotsam, but never large schools. Tuna were a minor portion of the observed fish assemblages. Hunter and Mitchell (1968) postulated a connection between schooling behavior and the attraction of fish to flotsam. They concluded that flotsam had the function of providing (p. 27) " . . . a visual stimulus in an optical void." Gooding and Magnuson (1967) concluded that fish gathered around floating objects at sea primarily because the objects provided shelter from predation. It may be possible that the same factors attracting smaller fish also attract large tuna schools.

This paper examines historical tuna fishery data on the catches of yellowfin and skipjack tuna associated with floating objects in the eastern tropical Pacific from 1963 to 1975. The objectives of the paper are to 1) establish the main sources of flotsam, 2) determine if there is a connection between various set types, 3) see if flotsam-associated sets have become more important to the tuna fishery, 4) determine if the catch rate on flotsam-associated sets has changed, and 5) assess whether flotsam does aggregate tuna schools.

## METHODS

Since the catch of tuna associated with flotsam depends on the presence of tuna, flotsam, fishermen, strength of attraction, and suitable fishing conditions, I examined each factor in light of the published literature and available fishery data from the eastern tropical Pacific tuna fishery.

The Inter-American Tropical Tuna Commission (IATTC) collects information from tuna fishermen operating in the eastern tropical Pacific. Information collected in logbooks includes date and location of sets, catch of various species, type of set, and environmental conditions. Although these logbooks remain confidential, it is possible to obtain summaries of the information for certain time-area strata. During the beginning portion of

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the year, yellowfin tuna fishing is unregulated. After a quota is reached (Table 1), all yellowfin tuna fishing, except for special allowances must be outside the Commission's Yellowfin Regulatory Area (CYRA) (Figure 1). Due to special rules (see Inter-American Tropical Tuna Commission 1967-1975), any detailed reporting of regulated data would compromise the confidentiality of the data; hence, only unregulated catch and number of sets within the CYRA summarized by month and 5° square for 1963-75 were made available to me.

TABLE 1.—Yellowfin quota (thousands of short and metric tons), closure data, and annual total catch (thousands of short and metric tons) for the Commission's Yellowfin Regulatory Area, taken from Calkins (1976).[1] Metric tons are given in parentheses.

| Year | Quota | Quota + increment[2] | Closure date | Annual total catch |
|---|---|---|---|---|
| 1966 | 79.3 ( 71.9) | | Sept. 15 | 91.1 ( 82.6) |
| 1967 | 84.5 ( 76.6) | | June 24 | 89.6 ( 81.3) |
| 1968 | 106.0 ( 96.1) | | June 18 | 114.6 (103.9) |
| 1969 | 120.0 (108.8) | | Apr. 16 | 126.5 (114.7) |
| 1970 | 120.0 (108.8) | | Mar. 23 | 142.6 (129.3) |
| 1971 | 140.0 (127.0) | | Apr. 9 | 113.9 (103.3) |
| 1972 | 120.0 (108.8) | 140.0 (127.0) | Mar. 5 | 152.5 (138.3) |
| 1973 | 130.0 (117.9) | 160.0 (145.1) | Mar. 8 | 177.8 (161.3) |
| 1974 | 175.0 (158.7) | 195.0 (176.9) | Mar. 18 | 191.3 (173.5) |
| 1975 | 175.0 (158.7) | 195.0 (176.9) | Mar. 13 | 177.2 (160.7) |
| 1976 | 175.0 (158.7) | 195.0 (176.9) | Mar. 27 | 205.5 (186.4) |

[1]Calkins, T. P. 1976. The 1976 fishing year (through August 30). Background Paper No. 1, 33rd meeting of the Inter-American Tropical Tuna Commission.
[2]The Director of IATTC may increment the established quota, allowing more yellowfin tuna to be caught.

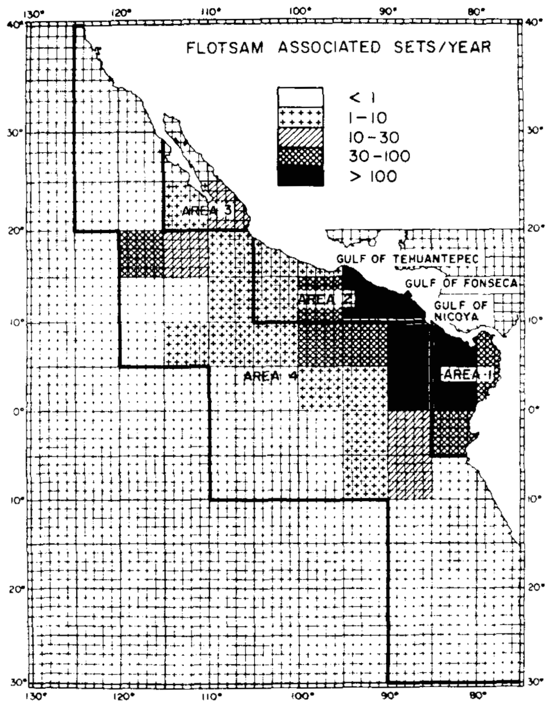



FIGURE 1.—Eastern tropical Pacific fishing area divided into three nearshore areas (Areas 1-3) and one offshore area (Area 4). The heavy line to the west delimits the boundary for the Commission Yellowfin Area (CYRA). The average number of flotsam-associated sets from 1972 to 1975 by 5° squares is shown. Data represent the unregulated fishing period (see text).

The total number of unregulated sets during the 13 yr was approximately 161,000 of which 8,190 were associated with flotsam. In addition, the IATTC provided the total number of flotsam-associated sets occurring each year (Figure 2). One sees that the major trends in the number of sets are contained in the block of unregulated data.

NOAA's Southwest Fisheries Center (SWFC) periodically sends technicians aboard tuna seiners. These technicians record details about set type, catch, environmental conditions, as well as the fork length (centimeters) of tuna sampled from individual sets. Fork lengths of yellowfin and skipjack tuna were only available for a limited number of sets made in 1973-75. The location of fork length measurements are given in Table 2. Single set catch data were collected by SWFC technicians in 1974-76 (unpubl. data[2]).

[2]Unpubl. data on file at the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

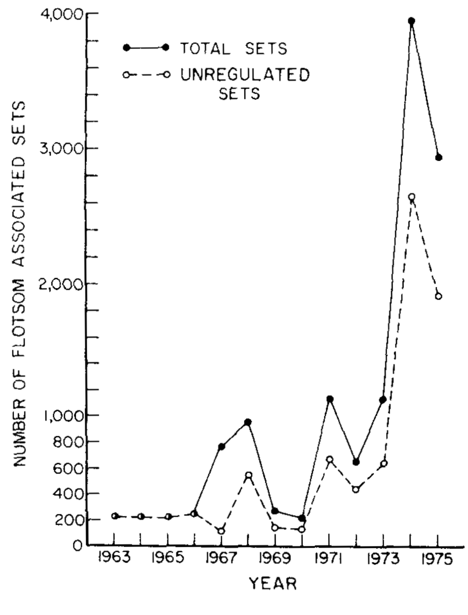



FIGURE 2.—Total number of flotsam-associated sets made in the eastern Pacific and number of unregulated flotsam-associated sets made in the CYRA, 1963-75.

TABLE 2.—Spatial distribution of fork length measurement (centimeters) of yellowfin and skipjack tuna in the Commission's Yellowfin Regulatory Area, 1973-75. CYRA subareas are shown in Figure 1. (Source of data, SWFC.)

| CYRA subarea | Number of sets where fork length was measured |
|---|---|
| 1 | 56 |
| 2 | 12 |
| 3 | 14 |
| 4 | 29 |

Monthly rainfall in Central America was calculated by averaging the stations reporting to the Environmental Data Service (U.S. Department of Commerce 1963-1975).

In order to achieve the objectives of this paper, the data obtained from IATTC and SWFC were examined and analyzed in several ways. The main sources of flotsam were inferred by examining the average distribution of flotsam-associated sets and consideration of the average surface circulation.

Two methods may be used to determine if different set types are related: correlation of set types occurring in an area and comparison of fork length distributions (length-frequency graphs) stratified by species and set type. Spearman's rank correlation coefficient (Siegel 1956) was calculated to expose possible correlations of numbers of sets. Fork length distributions were weighted by the catch in each set. A high positive correlation between set types occuring in an area would indicate a relationship between set types. Similar looking length-frequency distributions would serve as further evidence that set types are related.

An increase in the percentage of flotsam-associated sets would be evidence that flotsam-associated sets have become more important to the fishery. The CYRA was subdivided into three nearshore areas and one offshore area (Figure 1). Stratifying the number of flotsam-associated sets by area allows the determination of area effects. Hence, the importance of flotsam to the fishing industry may be determined by the percentage of flotsam-associated sets occurring each year and stratifying the number of flotsam-associated sets by area.

Average rainfall was tabulated to determine if any connection existed between river runoff and the number of flotsam-associated sets.

Catch rate is an indicator of the importance of flotsam-associated sets to the tuna fishery. Calculation of the average yearly catch per set (including zero catch sets) for different set types should demonstrate any trends as well as the relative value of making one set type over another.

Calkins (1965) examined tuna length distributions from single sets in the eastern tropical Pacific, finding that single unassociated schoolfish sets caught tuna of a relatively uniform size (i.e., small variance in length). If the fish caught in flotsam-associated sets represent aggregations of solitary tuna, portions of schools, or several schools, then one would expect the variance of tuna length to be greater than for unassociated schools. In order to examine if floating objects act as aggregators, length-frequency data were stratified by species and set type. Mean length and standard deviation were calculated on a single set basis for each category and compared using Kruskal-Wallis one-way analysis of variance by ranks (Siegel 1956).

If flotsam does aggregate tuna, one would expect more of the larger flotsam-associated sets than unassociated sets. Differences in catch distribution were observed by plotting histograms of tons of tuna caught per set stratified by year and set type and by calculating catch per successful set for each year and set type. The single set catch data, collected by SWFC technicians, existed for the 1974-76 period.

## RESULTS

The availability of logs or other flotsam in an area are determined by the source of the flotsam and the currents in the area. Large rivers flow into the Pacific from southern Mexico (lat. 20°N) and continue down the coast of South America (to lat. 20°S). These rivers are capable of releasing many logs into the Pacific during the rainy season. SWFC and IATTC observers reported large densities of logs near the Gulf of Tehuantepec (lat. 16°N, long. 100°W), the Gulf of Nicoya (lat. 10°N, long. 85°W), and the Gulf of Fonseca (lat. 13°N, long. 87°W).

The average yearly number of flotsam-associated sets in 1972-75 were plotted by 5° squares (Figure 1). In general, most flotsam-associated sets occurred in Areas 1 and 2. Most of the offshore flotsam-associated sets (i.e., Area 4) occurred quite close to Areas 1 and 2. Area 3 did not have large numbers of flotsam-associated sets. If the main source of logs and other flotsam is the rivers of Central America, then it is important to examine the major current patterns in the eastern tropical Pacific to determine if the currents can explain the observed distribution of flotsam-associated sets.

The average currents in the eastern tropical Pacific, as derived from ship's drift data, were determined by Wyrtki (1965). From January until May, the California Current is strong. Circulation near Area 3 is to the south. Circulation near Areas 1 and 2 is gyral. From May to July, both the Equatorial Countercurrent and the California Current are relatively stong. During this period, most countercurrent water turns north and flows along the coast of Central America. Area 3 has a northern and southern flow, the northern flow along the coast. Area 1 maintains its gyral flow. From August through December, the Equatorial Countercurrent is well developed. Circulation in Area 3 is to the south. Area 2 maintains its northwestern flow along the coast and Area 1 flow maintains a gyral pattern. If logs disperse mainly from the Gulf of Nicoya, the Gulf of Tehuantepec, and the Gulf of Fonseca, then the gyral circulation in Area 1 would tend to maintain logs and other flotsam in the area for a considerable time. The northwest coastal current in Area 2 could transport flotsam through Area 2 and during part of the year into Area 3. Since the North Equatorial and South Equatorial Currents are rather strong, one would not expect floating objects to persist in Area 4 except near the boundaries with Areas 1 and 2. Hence the location of large rivers and the system of currents is reasonably consistent with the geographical distribution of flotsam-associated sets.

In order to compare different set types, Spearman's rank correlation coefficient was calculated. For each 5° square in the CYRA, the total numbers of flotsam-associated sets, porpoise-associated sets, and unassociated schoolfish sets were tabulated for each year. These totals were ranked and the ranks were correlated. Only 5° squares where at least 10 sets occurred were used in calculating correlations. When a minimum of 40 sets was used as the criterion for including a 5° square, the correlations were qualitatively the same as with the 10 sets criterion. The results (Table 3) show that a significant positive correlation exists between number of sets on unassociated schoolfish and flotsam-associated tuna. Porpoise sets were uncorrelated with other set types.

The above results indicate that fish caught associated with flotsam tended to be caught in the same area at the same time as unassociated school fish. Examination of available length-frequency data on a species basis, weighted by the catch in each set (Figure 3), indicated that unassociated schoolfish and flotsam-associated yellowfin and skipjack tuna had very similar length-frequency distributions. The length-frequency information and the correlation analysis support the idea that unassociated tuna and flotsam-associated tuna are related. Flotsam, acting as an attractant, may aggregate tuna that would otherwise be caught in unassociated sets.

TABLE 3.—Spearmans rank correlation between three types of sets by year. Number of sets/5° square. (Source of data: IATTC.)

| Year | $N$ | Unassociated schoolfish and porpoise-associated | Unassociated schoolfish and flotsam-associated | Porpoise and flotsam-associated |
|---|---|---|---|---|
| 1963 | 29 | -0.0008 | 0.5421** | 0.2538 |
| 1964 | 27 | 0.0375 | 0.1581 | 0.8138** |
| 1965 | 25 | -0.1597 | 0.3498* | 0.1318 |
| 1966 | 28 | -0.1110 | 0.3513* | 0.2914 |
| 1967 | 24 | -9.2379 | 0.4621* | -0.2255 |
| 1968 | 24 | -0.1951 | 0.1886 | 0.3463* |
| 1969 | 25 | -0.1523 | 0.5957** | 0.2294 |
| 1970 | 27 | -0.0088 | 0.3529* | -0.0173 |
| 1971 | 26 | 0.0803 | 0.5819** | 0.2398 |
| 1972 | 32 | -0.0200 | 0.5277** | -0.0558 |
| 1973 | 34 | 0.0523 | 0.3086* | 0.1796 |
| 1974 | 27 | 0.0168 | 0.4847** | 0.0001 |
| 1975 | 33 | 0.2444 | 0.5139** | 0.0526 |

*Significant at $P \leq 0.05$.
**Significant at $P \leq 0.01$.

The number of flotsam-associated sets has increased dramatically since 1971 (Figure 2). The trend in percentage of flotsam-associated sets (Figure 4) indicates that flotsam-associated sets have increased in importance to the fishery. Stratifying the number of unregulated flotsam-associated sets by area (Figure 5) shows that the trend of more flotsam-associated sets is not an area effect. All areas, except Area 3, have shown a marked increase in number of flotsam-associated sets. Area 3 does not show an increase because logs are only deposited in this region during a limited portion of the year. In January-May, the near surface current in Area 3 is to the south (Wyrtki 1965), cutting off the source of logs that wash down the rivers of Central America. Also, good fishing often occurs in Area 3 during the later months of the year, a period not included in my unregulated data. It appears that the increase in flotsam-associated sets in recent years was not caused by discovery of new areas with abundant flotsam but rather by an increase in fishing effort on flotsam in all areas but Area 3.

Average rainfall in Central America was tabulated (Table 4) to see if there was a correlation between river runoff and the number of flotsam-associated sets. Comparison of number of flotsam-associated sets and rainfall revealed only

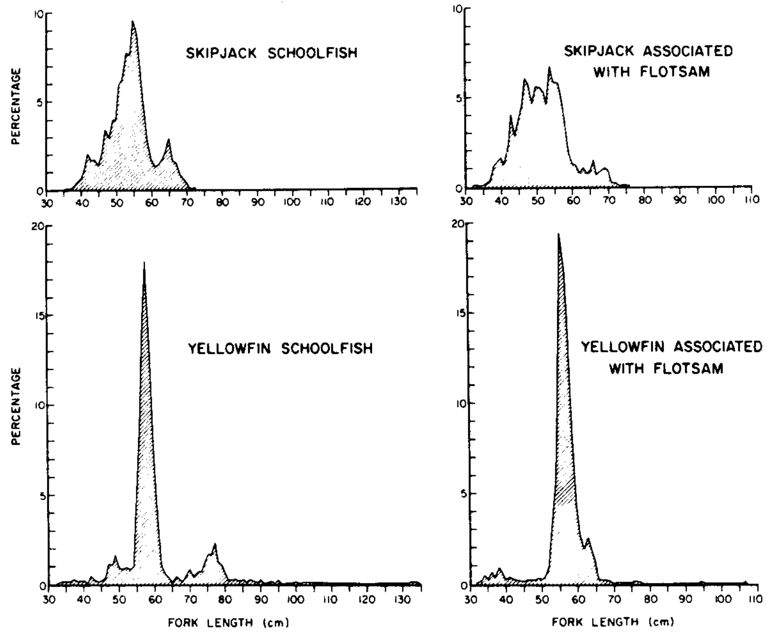



FIGURE 3.—Length-frequency distributions of yellowfin and skipjack tuna caught in unassociated schoolfish and flotsam-associated sets. Data collected 1973-75 in the CYRA (see Table 2).

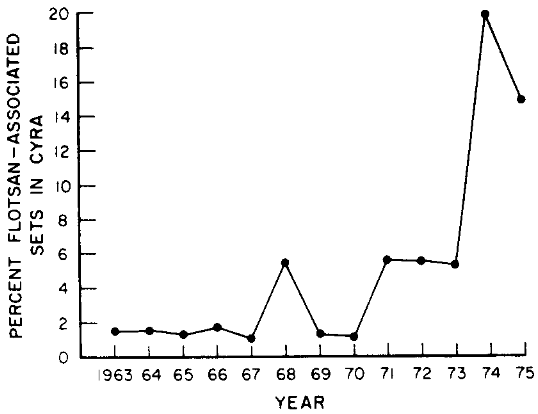



FIGURE 4.—Percentage of total unregulated sets that were associated with flotsam in the CYRA, 1963-75.

small similarities, indicating that the supply of suitable flotsam was not greatly influenced by rainfall.

Comparing the average catch per set of different set types indicates the relative importance of each set type to the fishery as well as showing trends in the catch rate (Figure 6). All set types had similar catch rates in 1963-66. Porpoise sets and flotsam-associated sets gave much higher catch per set than unassociated sets in 1971-75. One sees that flotsam-associated sets have been the most valuable set type for the tuna fisherman since 1971.

TABLE 4.—Average yearly rainfall (centimeters) in Central America in 1963-75. (Source: U.S. Department of Commerce.)

| Year | Average yearly rainfall | Year | Average yearly rainfall |
|---|---|---|---|
| 1963 | 139.0 | 1970 | 163.8 |
| 1964 | 136.4 | 1971 | 145.5 |
| 1965 | 136.9 | 1972 | 145.6 |
| 1966 | 158.5 | 1973 | 161.4 |
| 1967 | 151.7 | 1974 | 172.3 |
| 1968 | 177.3 | 1975 | 151.0 |
| 1969 | 177.2 | | |

Fork length data was stratified by set type and species. The mean length, standard deviation, and sample size were calculated on a single set basis (Table 5). The average standard deviation of fork length of yellowfin and skipjack tuna associated with flotsam was larger than the standard deviation found in unassociated sets, though the mean fork length of flotsam-associated sets was smaller. The probability of getting the results shown (Table 5) by chance was calculated using Kruskal-Wallis one-way analysis of variance (Siegel 1956:184) (Table 5). The greater variability of fork length of flotsam-associated tuna supports the hypothesis that flotsam aggregates tuna.

The yellowfin and skipjack tuna catch distribution on flotsam-associated sets was compared with unassociated schoolfish sets. The average catch per successful set was calculated and the data were plotted as histograms of tonnages using an arbitrary interval of 5 tons (Figure 7). The main

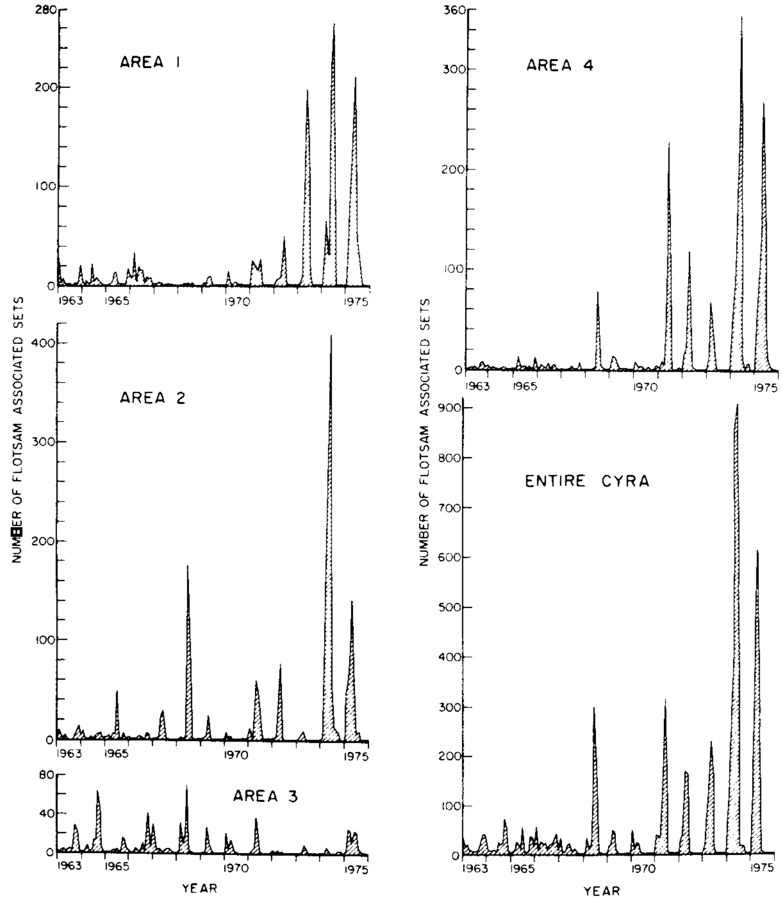



FIGURE 5.—Number of unregulated flotsam-associated sets per month by area, 1963-75.

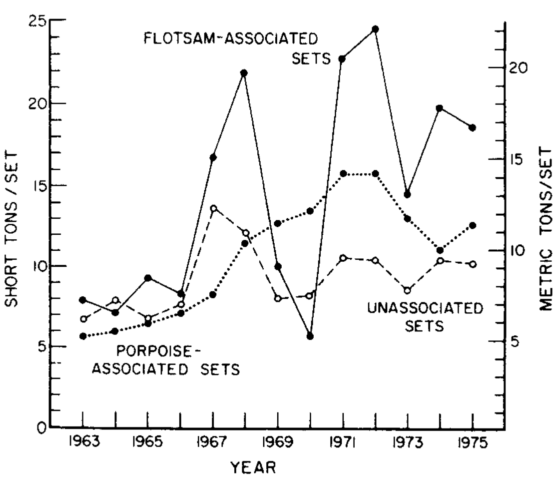



FIGURE 6.—Average yearly catch per set of yellowfin and skipjack tuna in flotsam-associated, unassociated schoolfish, and porpoise-associated sets in the CYRA.

differences between the histograms for unassociated schoolfish sets and flotsam-associated sets are a lower proportion of unsuccessful sets and a higher percentage of flotsam-associated sets with catches between 25 and about 60 tons. The higher proportion of large flotsam-associated sets is consistent with the hypothesis that flotsam aggregates tuna.

## DISCUSSION

Changes in catch rate (catch per set, Figure 6) of flotsam-associated yellowfin or skipjack tuna may be related to overall abundance of flotsam-associated schools, technological advances such as bigger nets, increased skill and knowledge of the fishermen, changes of the attractability of flotsam, and changes in the residence time of tuna with flotsam. In order to explain the observed increase

TABLE 5.—Variability of fork length (centimeters) in single set data by tuna species and set type, as indicated by average standard devation ($\bar{S}$) and mean ($\bar{x}$) and results of Kruskal-Wallis one-way analysis of variance of standard deviations. (Source of data: SWFC.)

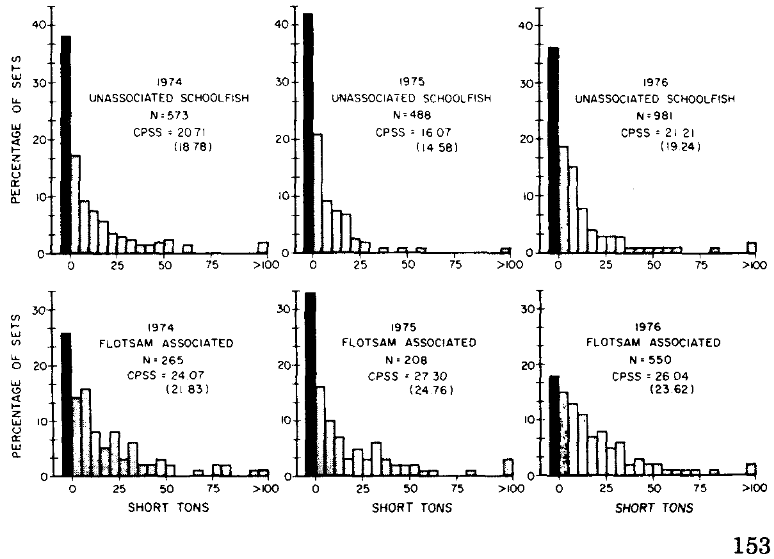
| Item | Yellowfin tuna | Skipjack tuna |
|---|---|---|
| Flotsam-associated sets: | | |
| $N$ | 35 | 45 |
| $\bar{S}$ | 4.96 | 4.62 |
| $\bar{x}$ | 55.55 | 52.49 |
| Unassociated schoolfish: | | |
| $N$ | 49 | 43 |
| $\bar{S}$ | 3.76 | 3.40 |
| $\bar{x}$ | 60.94 | 54.08 |
| Kruskal-Wallis: | | |
| $H$ | 3.69 | 33.31 |
| df | 1 | 1 |
| Probability level | $0.05 \leq P \leq 0.1$ | $P \leq 0.001$ |

in catch rate, it was necessary to examine data that could indicate which factors have most influenced catch rate. Changes in attractability, changes in residence time, technological advances, and increased knowledge of the fisherman could not be rejected or confirmed with existing data. It was possible, with some assumptions, to determine if overall abundance changes or increased skill of the fisherman could explain the increased catch rate.

If the overall abundance of tuna had increased from 1963 to 1975, then one would expect the catch rate to have increased correspondingly. If one accepts the supposition that flotsam-associated fish were from the same population as unassociated schoolfish, then one would expect the catch rate on unassociated schoolfish to have likewise increased. The catch per set on unassociated schoolfish (Figure 6) showed no increase. However, the year-to-year variations in catch per set of flotsam-associated tuna and unassociated tuna (Figure 6) were remarkably similar. The above evidence indicates that changes in overall abundance does not explain the long-term increase of catch per set in flotsam-associated sets. The similarity of the year-to-year variations supports the hypothesized relationship between unassociated schoolfish and flotsam-associated tuna. The year-to-year variation may represent changes of abundance.

The second explanation for the changes in the catch rate of flotsam-associated tuna schools, changes in the skill of the fisherman, can be evaluated by the percentage of successful sets. An increase in the percentage of successful sets on schools associated with flotsam would explain the apparent increase in catch per set. Such an explanation is untenable because the percentage of successful sets would have had to more than double. Greenblatt (1977) calculated the percentage of successful sets associated with flotsam for 1974-76, finding the average percentage of successful sets to be 75%. To account for the change in catch/set, the percentage of successful sets in 1963 would have had to have been about 35%, an unreasonably low figure. Pella and Psaropulos (1975, fig. 2) showed that the percentage of successful sets of unassociated schoolfish sets and flotsam-associated sets (considered as one category) did not increase enough in 1961-71 to account for the observed changes in catch per set. Bayliff and Orange (1967) reported percentages of successful sets stratified by set type for a limited area of the

FIGURE 7.—Distribution of catch by 5 short ton intervals for flotsam-associated sets and unassociated schoolfish from 1974 through 1976. Solid boxes indicate percentage of zero catch sets. The average catch per successful set (CPSS) in short and metric tons is given for each category. Metric tons are in parentheses.



CYRA. Although they had small numbers of sets, the percentage of successful flotsam-associated sets from 1962 to 1966 was 67.6%. Changes in percentage of successful sets can not adequately explain the increased catch per set.

No satisfactory explanation for the increase in catch per flotsam-associated set has been found. Overall increases in abundance or increased skill of the fishermen can not explain the increase. The above factors may account for some of the increase. Technological advances may account for the increased catch rate. It is also reasonable to believe that fishermen have learned to catch flotsam-associated tuna more efficiently and the residence time of tuna with flotsam has increased since 1967.

Changes in catch per set on flotsam-associated sets may have been due to technological advances such as bigger nets. If technological advances can explain the increased catch per set on flotsam, then either the catch per set on unassociated schoolfish should have also increased or sets associated with flotsam prior to the technological advances must have caught a low proportion of potential catch. Nets have increased in size, perhaps increasing the probability of catching yellowfin and skipjack tuna which may aggregate around flotsam. It is possible that bigger nets could account for increased catch/set of flotsam-associated sets without likewise affecting catch/set on unassociated schoolfish sets.

Fishermen often will drift with logs for considerable time, waiting for tuna aggregations to reach an optimal size before setting the net. The spread of such behavior throughout the fleet could cause the overall catch per set of flotsam-associated tuna to increase. Adequate data for testing this "increased knowledge" hypothesis was unavailable.

The marked changes occurring in flotsam-associated tuna catch in 1963-75 coincided with a large increase of effort and technology in the porpoise-associated fishery (Green et al. 1971). It is hypothesized that the increased effort and technology in the porpoise-associated fishery may have been related to changes in the catch rate of tuna schools associated with flotsam.

When purse seiners set on porpoise, there is often an incidental kill of the marine mammals. Due to recent technological advances, the porpoise kill has been reduced, but in earlier years of the porpoise-associated fishery (the mid-1960's) porpoise mortality was higher (Southwest Fisheries Center[3]). This incidental kill may have reduced the porpoise population. The porpoise-associated fishery first developed near shore and thus the nearshore porpoise stocks have been affected for a longer time than offshore stocks. One may reasonably speculate that, on a species basis, nearshore porpoise stocks have been affected more by incidental kills than offshore porpoise stocks.

The bond between tuna and porpoise is not understood. It is possible that the mechanisms involved in the association of tuna with porpoise is similar to those responsible for their association with flotsam. Tuna associated with flotsam are, on the average, smaller than tuna associated with porpoise (Calkins 1965, tables 2 and 9; Sharp[4]). Knudsen (1977) gave some evidence that tuna caught in areas where porpoise fishing predominates were generally older and larger than in traditional schoolfish areas. Size overlap, however, did occur (Calkins 1965). Assuming that the number of porpoise schools have declined, the probability of tuna encountering porpoise schools has decreased. The probability of tuna aggregated near flotsam encountering porpoise schools has also decreased. Thus, as a result of decreased encounter rates with porpoise (slower transition from flotsam to porpoise), the size of the aggregations of tuna near flotsam have increased.

In conclusion, the most likely sources of flotsam are the large rivers of Central America. Indirect evidence indicates that tuna caught in unassociated schoolfish sets are from the same population as tuna caught associated with flotsam. It appears that the increase of flotsam-associated sets from 1963 to 1975 was due to an increased interest by fishermen and hence an increased fishing effort on floating objects. The observed increase in catch per set may have been a biological change rather than a change in fishing technology or skill.

## ACKNOWLEDGMENTS

I would like to express my thanks to John Hunter who provided guidance in several phases of this study. His comments were extremely help-

[3]Southwest Fisheries Center. 1976. Report of the Workshop on Stock Assessment of Porpoises Involved in the Eastern Tropical Pacific Yellowfin Tuna Fishery. SWFC Adm. Rep. LJ-76-29, 54 p. Southwest Fisheries Center, La Jolla, CA 92038.

[4]G. Sharp, Inter-American Tropical Tuna Commission, Southwest Fisheries Center, La Jolla, CA 92038, pers. commun. April 1977.

ful. Richard McNeely first suggested the possible interaction of porpoise and flotsam-associated tuna. The Inter-American Tropical Tuna Commission provided much of the data. William Flerx and Richard Charter provided insight into the operation of the fishery. Gary Sharp provided useful information about yellowfin tuna. Rainfall data were obtained from Eric Forsbergh. William Lenarz, Douglas Chapman, and Robin Allen reviewed the paper and offered constructive comments.

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