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INVESTIGATIONS ON WESTERN PACIFIC YELLOWFIN FISHERY INTERACTION USING CATCH AND EFFORT DATA

(Paper Prepared by the Secretariat)

Introduction

1. The amount that regional tuna stocks are shared between countries and fleets of tuna boats continues to be an area of concern for several Pacific Island countries. The Tuna and Billfish Assessment Programme (TBAP) , with the direction of member countries, investigates the potential interaction between fisheries through studies of the fisheries and the biology and population dynamics of the tuna being fished. As outlined in SPC/Fisheries 20/Information Paper 5, there are three general approaches to assessing the level of sharing or interaction between tuna fisheries :

- using descriptive statistics on catch and effort from the individual fisheries ;
- employing age or size-structured statistical models to examine resource use by the different fisheries and the relative impacts they may or may not have on each other; and
- conducting tagging studies.

2. The purpose of this paper is to present some descriptive characteristics of the purse seine and longline fisheries with respect to yellowfin catch rates and to open discussion on the issue of detecting interaction using catch and effort data. In the first and second section the nature of longline and purse seine fisheries is outlined with particular reference to factors that influence catch rates. The third section compares longline catch rates from two different areas–one where little purse seining occurs and the other where the purse seine fishery is highly active. The fourth section compares purse seine and longline catch rates on a seasonal and monthly basis giving special consideration to purse seine set types.

The Longline Fishery

3. For the purpose of this investigation, data were selected from Japanese longline vessels only. The level of accuracy and the consistency of reporting by Japanese longline vessels is the highest among the longline fleets (SPC 1987). Longline catch of yellowfin is recorded here in numbers of fish because average weight information is not always consistently supplied.

Fishing Depth

4. Several authors have investigated the effect of longline fishing depth on catch rates of certain species and found significant differences between longline fishing strategies (e.g. Suzuki et al. 1977; Koido 1985). Generally, yellowfin catch rates are lower for gear that fish deeper than 150 metres while catch rates for the more valuable bigeye are higher at these greater depths. In published accounts of yellowfin hooking rates, however, differences in fishing depth have not been incorporated as a factor affecting indices of apparent abundance. The data were thus re-examined for the effect, if any, of longline hook depth on yellowfin catch rates in the Western tropical Pacific.

5. Suzuki et al. (1977) stated that the number of hooks per basket can indicate whether longline gear is fishing in deep water or the more traditional, shallow lines are being set. He stated that less than 7 hooks per basket could be classified as shallower fishing gear and that above 10 hooks per basket should be considered as deep gear. The SPC longline data plotted annually as distributions of hooks per basket show that there is a considerable mix of the different set types (Figure 1).

6. The next step was to examine the relationship between hooks per basket and fishing depth. Using the formula given by Suzuki et al. (1977) and data from the SPC database that included the branch-line length, float-line length, main-line length between floats, the number of hooks per basket, and a constant sagging ratio of 0.60, mean hook depths were calculated for each set. Two distinct groups of mean hook depth were found. For sets with less than 8 hooks per basket the mean depth was around 125 metres while sets with 8 or more hooks per basket had mean depths around 175 metres (Figure 2). Fishing depth appears to be influenced by factors other than just hooks per basket, however, to create a more accurate index means that much data must be overlooked because of missing values for any single variable used in the equation for fishing depth. If just hooks per basket is used as an indication of fishing depth, the volume of data available increases by over 30 percent. For this reason longline sets are classified as either conventional or deep : less than 8 hooks per basket is considered conventional gear; 8 or more hooks per basket is considered as deep longlining gear.

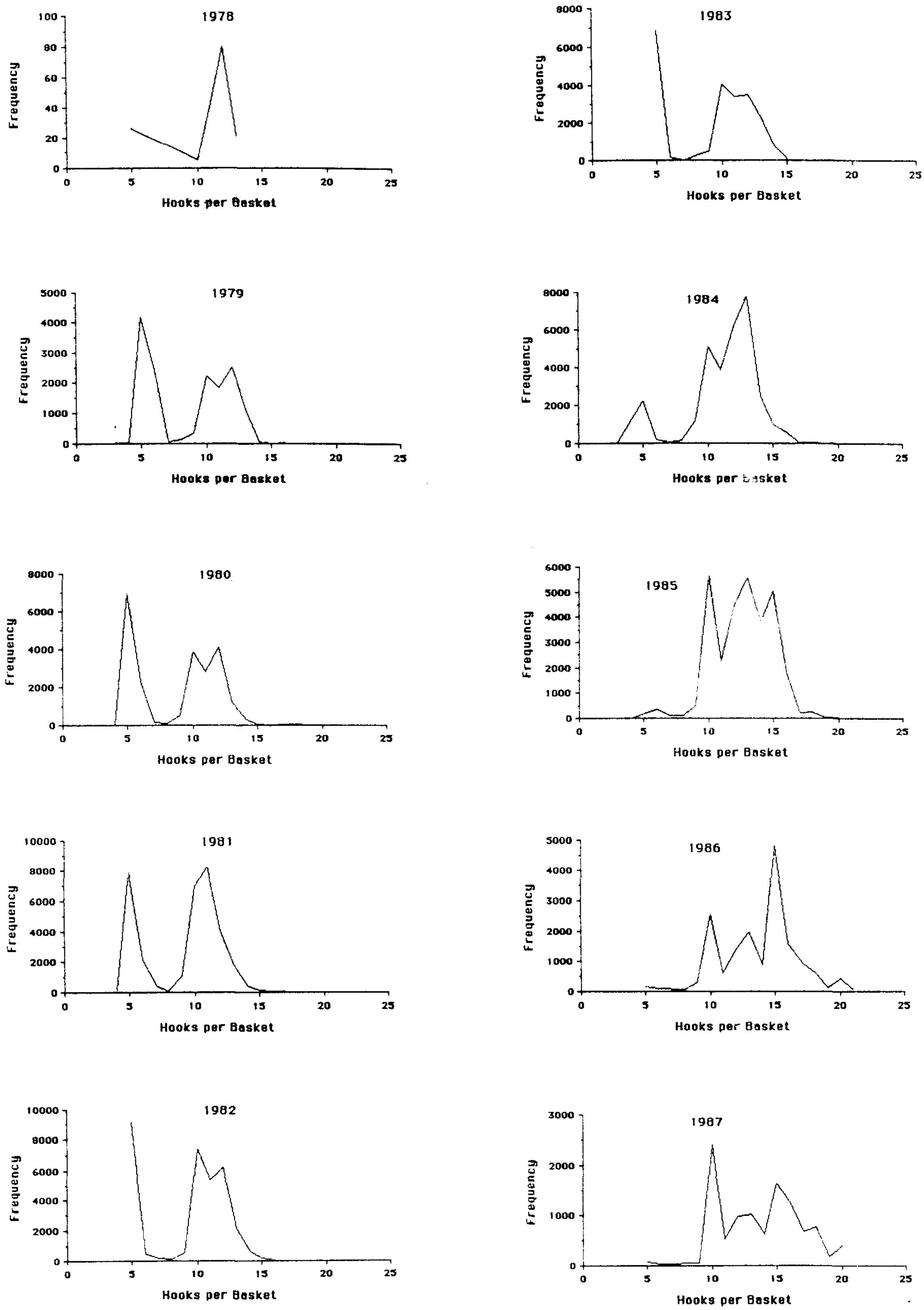

Figure 1. Annual frequency distribution of gear configurations (hooks per basket) of Japanese longline data processed at the SPC.

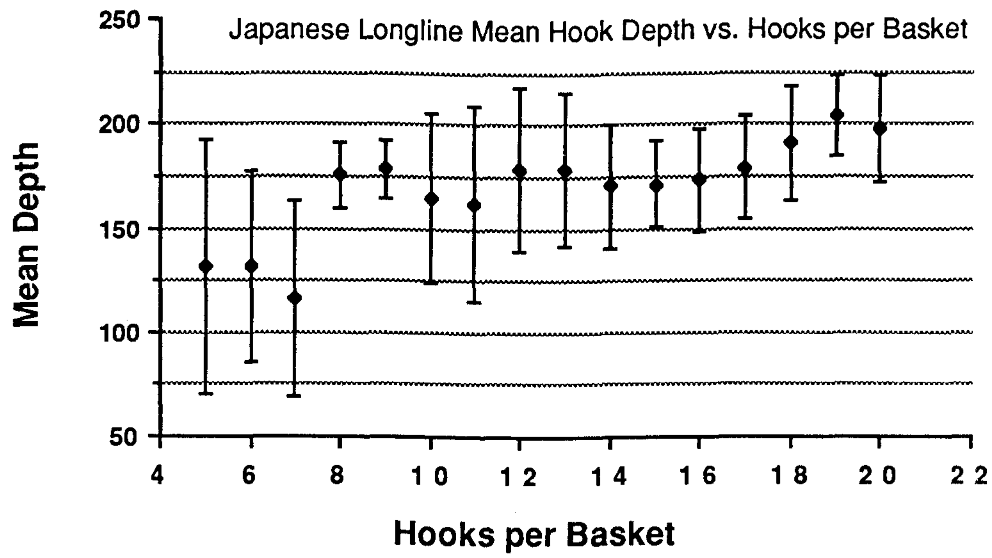

Figure 2. Average calculated mean hook depth versus hooks per basket. Error bars represent 1 standard deviation.

7. To compare deep and conventional gear, a general linear model was constructed after the method of Allen and Punsly (1984) and Punsly (1987). The two categories of fishing depth tested, as indexed by the number of hooks per basket, had a significant effect on catch rates (Table 1). The results concur with Suzuki et al. (1977) and Koido (1985) that fishing depth significantly affects longline yellowfin catch rates. The significant effect for the year component of the model can be used to derive catch rates more closely indicative of abundance. Preliminary results of adding other effects such as the depth of the 20 degree isotherm (as an index of thermocline depth), seasonal changes in the fishery (by quarter), geographic effects (2 degrees latitude by 10 degrees longitude), and the impact of purse seine catches are promising, however, the low coverage of fishing activities for the period concerned limits the usefulness of this type of analysis at present.

Table 1. Analysis of variance of the general linear model with the effect of year and fishing depth included, 1979-1988. (* denotes significant at 99.9% level)**

Source	df	SS	F
Year	9	188.7	48.3***
Fishing Depth	1	24.0	56.1***
Residual	3,964	1904.7	

Size Distribution of Longline Yellowfin

8. The distribution of yellowfin size from the different gear configurations reveals that roughly the same size groups are caught, however, the deeper gear tends to catch slightly greater percentages of the larger groups (Figure 3).

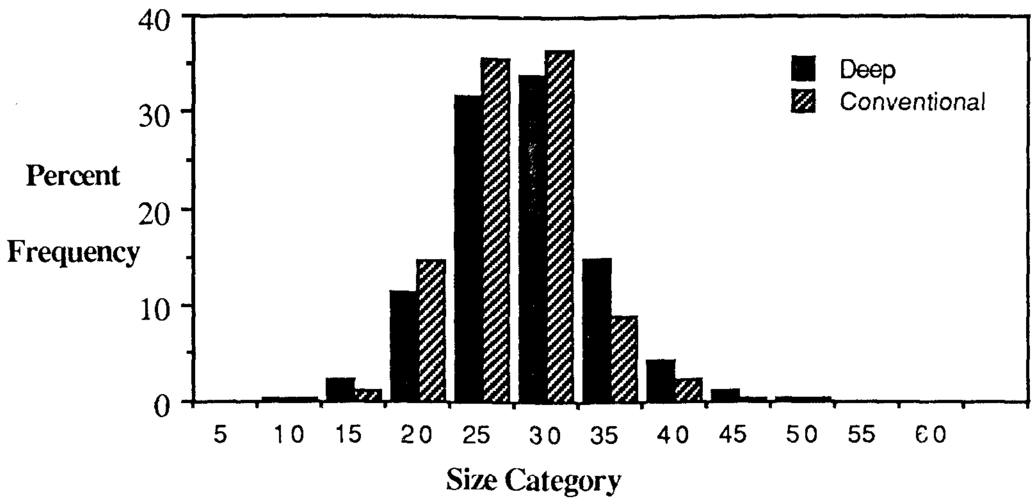

Figure 3. Average mean weights of yellowfin reported by Japanese longline vessels using deep and conventional gear, all data combined. The size category figures represent the upper limit of the 5 kg intervals.

The Purse Seine Fishery

9. For the purpose of this investigation data were selected from only Japanese purse seine vessels. The level of accuracy and the consistency of the reporting by the Japanese is the highest among the purse seine fleets (SPC 1987).

School Types

10. A major component of variation in catch rates from purse seiners can be attributed to the type of school in which the fish are found (Allen and Punsly 1984). In fact, the success of purse seining in the Western Pacific was in part due to increased proficiency at setting on drifting logs and debris under which tunas had aggregated. The more commonly found freely swimming surface schools are generally more difficult to catch because they can be fast moving and are generally set upon during daylight hours (log sets usually start just before dawn). Purse seine operators have probably become more proficient in setting on school-fish with practice and certainly gear modifications such as deeper nets, heavier chains to sink the net, lighter net material, and faster, more powerful purse winches has helped improve school-fish catch rates.

11. For the Japanese fleet, the proportion of sets on freely swimming schools (school sets) has increased while that for sets on floating logs or debris (log sets) has correspondingly declined, however the total number of log sets remains at a high level (Figure 4). The data for this analyses were classified according to these two categories of set types.

Purse Seine Catch Size Distribution by School Type

12. To describe the characteristics of the two general methods of purse seine fishing presented above, the size composition of the catch was examined. Records of yellowfin average weights per set plotted by 5 kg intervals and grouped by school type—either log sets or school-fish sets—shows that school-fish sets yield catches of larger yellowfin than log sets (Figure 5). Thus, for comparing direct interaction effects with longline gear, only days when sets were made on school-fish sets were considered when calculating purse seine catch rates.

Longline Catch Rates from Two Different Areas

13. Direct interaction between purse seine and longline yellowfin fisheries was examined from two pre-selected areas. In one area the longline fishery operates extensively and very little purse-seining occurs; in the other, both longline and purse-seine fisheries operate concurrently. The area with just the longline fishery will be referred to as area A (149E - 159E, 12N - 7N) and the area with both fisheries operating denoted as area B (141E - 151E, 03N- 02S). A comparison of longline catch rates in the two areas therefore provides a direct test of whether there are local effects of purse seining on longlining.

14. In this example, there appears to be a steady decline in longline yellowfin catch rates for deep gear in area B, where both purse seining and longlining occurs, whereas the longline catch rates in area A are variable but show no downward or upward trend (Figure 6). It appears that, to a certain extent, longline catch rates may be directly influenced by catches of purse seiners operating within the same area. This observation is clouded, however, by what appears to be a steady decline in longline catch rates from area B before purse seining was fully developed (1978-82, Figure 7). The yellowfin purse-seine catches do not appear to have an impact on longline catch rates outside of purse seine areas (i.e. area A). Extended over the data's full geographic range the longline yellowfin catch rates show a moderate decline (Figure 8).

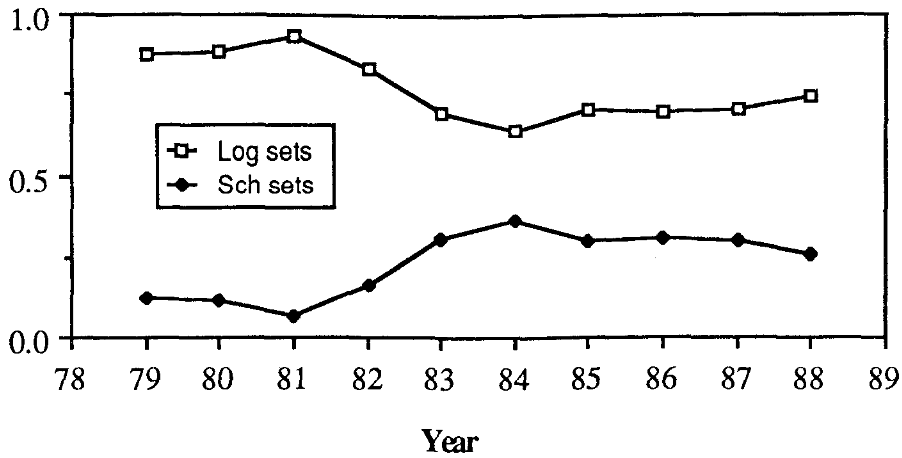

Figure 4. The proportion of purse seine set types by the Japanese fleet. "Sch" denotes sets on freely swimming schools while "Log" denotes sets around floating logs or debris.

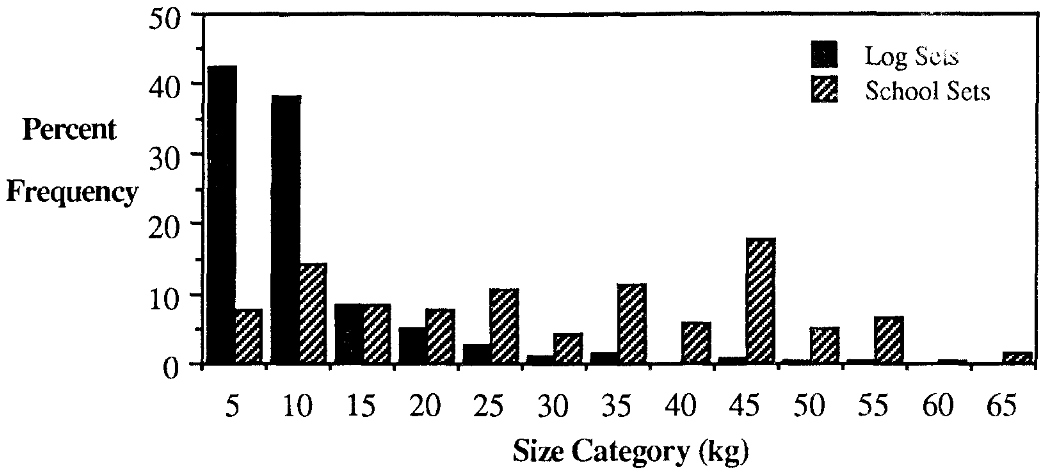

Figure 5. Percent frequency by weight of yellowfin average size from purse seine school-fish sets and log sets, 1978 - 1988 combined data. Size category figures represent the upper limit of each 5 kg interval. Catch where average weight was not reported is not included.

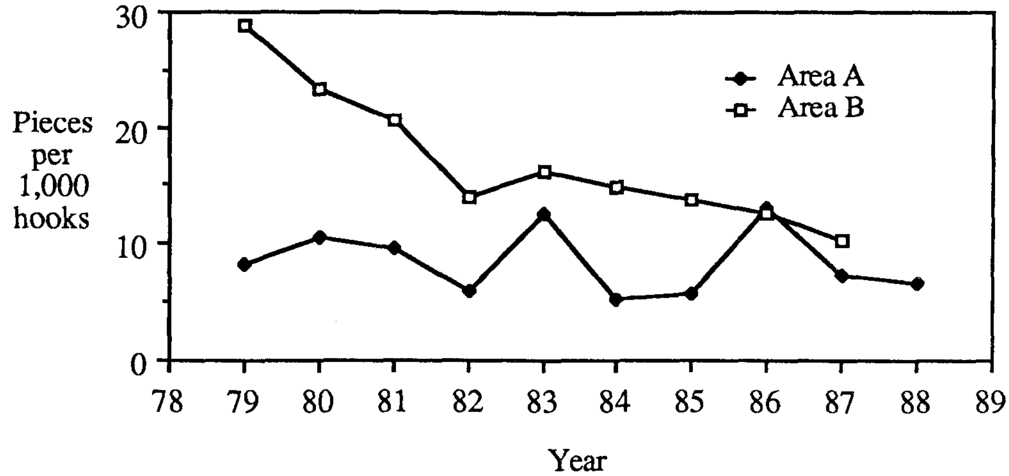

Figure 6. Longline yellowfin catch rates from area A, adjacent but outside of purse seine fishing grounds and area B, where both purse seining and longlining occurs.

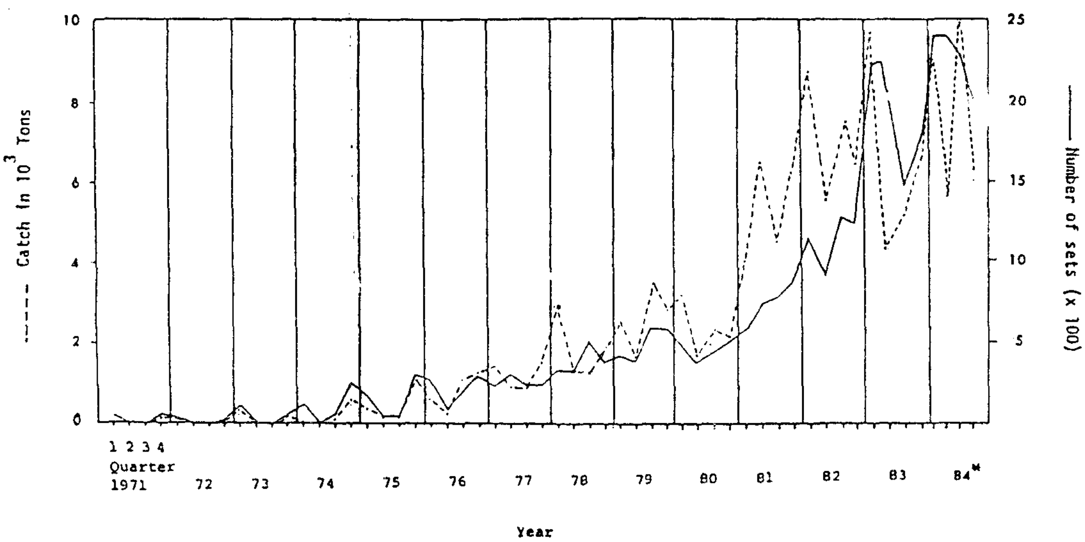

Figure 7. Japanese purse seine yellowfin catch and number of sets operating in the equatorial western Pacific. ***Source :*** **Suzuki and Koido 1986.**

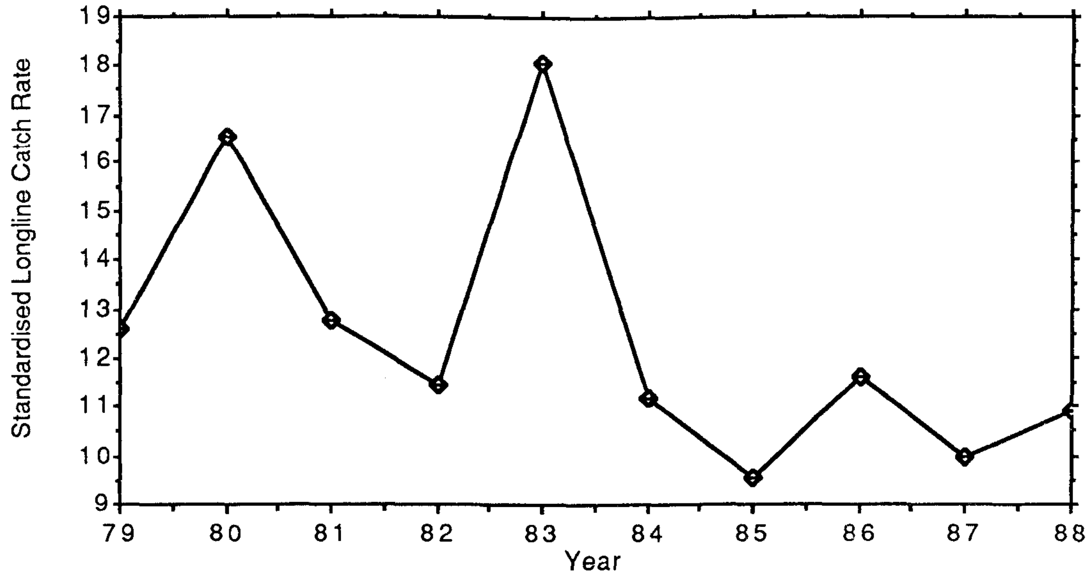

Figure 8. Yellowfin longline catch rates from the best fit general linear model standardising for depth of fishing from all fishing reported on logsheets between 15 degrees north and south latitude. Catch rate units are in numbers of yellowfin per 1,000 hooks.

Longline versus Purse Seine Catch Rates

Seasonal Patterns

15. Yellowfin catch rates from longline and purse seine gear within an area bounded by 10N, 140E in the northwest and 05S, 160E in the southeast were examined and compared for seasonal trends. To reduce the effect of changes in longline gear configuration, in particular the factors affecting fishing depth, longline catch rates were calculated from deeper fishing gears using 8 or more hooks per basket. Purse seine yellowfin catch rates were separated according to school type.

16. Yellowfin catch rates (metric tonnes per nominal day fishing) by purse seine sets on floating logs or debris (log schools) showed very little seasonal variation for combined years (Figure 9). Average yellowfin school-fish set catch rates, however, more than double between months. The yellowfin catch rate from longline gear in this area is also variable within different months of the year. Yellowfin seasonal catch rates from school fish purse seine sets and longline gear, when plotted together, appear negatively correlated for most months of the year (Figure 10). That is, for all years combined, monthly average catch rates are lowest for longlining in months when yellowfin catch rates are highest from purse seine school-fish sets and vice versa. Based on the size distributions of yellowfin taken from school-fish purse seine sets and longline gear, it is plausible that they are fishing the same stocks.

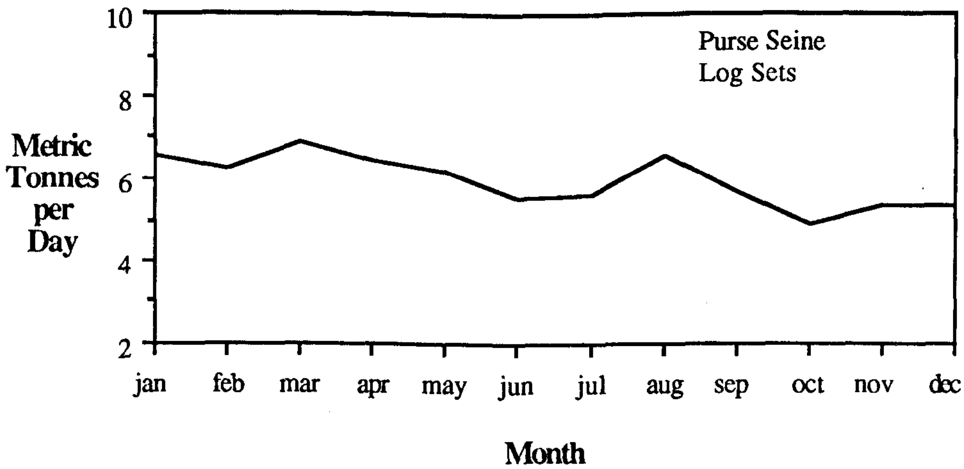

Figure 9. Yellowfin catch rates from log sets by month, 1978-1988 combined data.

17. There are several possible explanations for this. Yellowfin may become more vulnerable to surface purse seine school fishing during certain times of the year and consequently become less vulnerable to deep fisheries. Surface aggregations of (large) yellowfin in some areas have been observed to be engaged in spawning (Hisada 1973; McPherson pers. comm.). Based on gonadosomadic indices from longline and purse seine catches (Suzuki and Koido 1986) the spawning period occurs during the third and fourth quarter of the year. Oceanographic features may also indirectly affect the vulnerability of yellowfin to either gear.

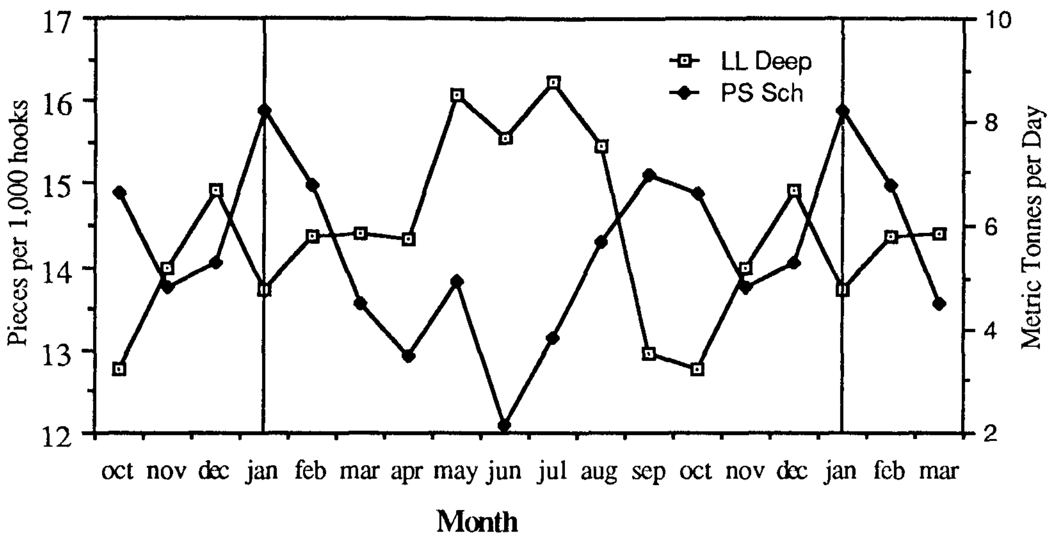

Figure 10. Seasonal patterns of yellowfin catch rates from longline vessels (left axis) and purse seine sets on school-fish (right axis), 1978 - 1988 combined data. The data from both gear types were selected from an area bounded by 10N, 140E in the northwest corner, and 05S, 160E in the southeast corner.

18. Monthly yellowfin catch rates standardised to have a mean of zero and a standard deviation of 1 plotted over time shows that month to month correlations between longline and purse seine catch rates again are largely negative (Figure 11). Assuming that the catch rates are an indicator of abundance, if yellowfin vulnerability to either gear type did *not* change and the stocks were shared, then we would expect the catch rates to be positively correlated. That is, as fishing conditions improved for one gear due to abundance, then they should also improve for the other. It is therefore possible that the predominately large yellowfin caught in school-fish sets by purse seiners are much the same fish taken by the longline fishery, although they are available to the fisheries at different times. It is also possible that the exchange between the two fisheries is with spawning behaviour.

19. The seasonal shifts in the geographic areas in which the purse-seiners operate may also influence the observed catch rate pattern. For example, the Japanese purse seine fleet generally tends to concentrate effort around the Equator during the fourth and first quarters, while during the second and third quarters they spend more effort between 5 and 10 degrees north latitude. The occurrence of yellowfin school-fish may be different between these areas and may explain the differences in catch rates.

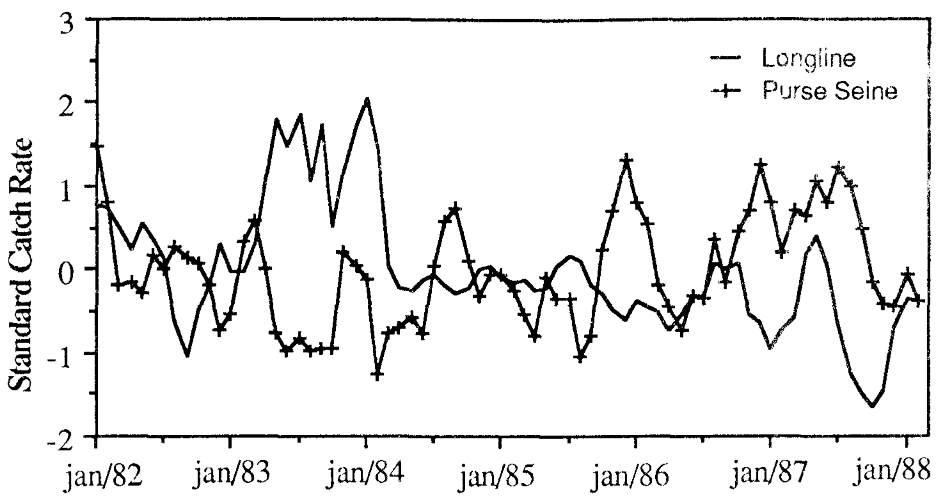

Figure 11. Monthly yellowfin catch rates from longline and purse seine school-fish sets standardised to have a mean of zero and standard deviation of one.

Summary

20. Catch rates of yellowfin by longline gear are strongly influenced by the fishing depth in the western tropical Pacific. An index of fishing depth within the database can be found based on hooks per basket, however, there is some variability in the hook depth based on other factors (float-line length, branch-line length and distance between floats). In the past ten years, records of Japanese longline fishing show that a significant proportion of the fishing was by conventional shallow gear (<8 hooks per basket) up until 1983. The size distribution of yellowfin caught using the deeper longlines is similar although slightly greater percentages of the larger size groups are represented.

21. Yellowfin catch rates from purse seiners are strongly influenced by the type of school being fished. School-fish sets or sets on non-associated schools by the Japanese fleet are becoming more frequent, however, sets on log or debris associated schools are still most common. The average weight distribution of the yellowfin catch from school-fish sets is considerably greater than from log sets, which concurs with Suzuki and Koido's (1986) findings. Due to the larger size yellowfin caught from school-fish sets, this type of fishing is thus more likely to have a direct effect on longline fishing conditions if yellowfin stocks are vulnerable to both gears.

22. Direct interaction effects were investigated by comparing longline yellowfin catch rate trends where longline and purse seine fishing occur concurrently with an area where only longline fishing occurs. In the area where both fisheries operate there was a steady decline in catch rates since 1979. In the area where only the longline fishery has operated, the catch rates have remained fairly constant. This case indicates that purse seine fishing may have an impact on longline yellowfin catch rates at sub-regional levels, however more areas need to be tested before the results can be regarded as conclusive.

23. Yellowfin catch rates from purse seine sets on school-fish and longliners have a strong negative correlation on a seasonal basis. Highest catch rates by longliners occur between March and August whereas this period is lowest for purse seine school-fish sets. Conversely, the highest catch rates for purse seiners occur between September and January during which time longline catch rates are lowest. This pattern may be linked to spawning behaviour as observed by Hisada (1973) and documented by Kikawa (1966) using gonadosomadic indices. If such is the case, it would appear that both gears have access to the same fish at different times and that the potential for this type of interaction will be greater if purse seiners concentrate more on school-fish sets. The impact of yellowfin purse seine catches from log sets on longline fishing is likely to be less given the smaller size composition of the catches. As more accurate size composition information on yellowfin catches becomes available the impact of catching smaller fish on "downstream" fisheries–both longline and purse seine–can be better evaluated.

24. In conclusion, descriptive fishery statistics are clearly useful indicators of interaction between fisheries. To further quantify the effects of purse seining on longlining a sound approach would be to develop a linear model that incorporates accurate information from the purse seine fishery since its development. As detailed purse seine and longline data are presently lacking from the major fleets during the early development of purse seine fishing in the western Pacific, such analyses have so far been inconclusive (SPC 1985).

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