FISHING PERFORMANCE OF SOME NATURAL AND CULTURED BAITFISH USED BY POLE-AND-LINE VESSELS TO FISH TUNAS IN THE CENTRAL AND WESTERN PACIFIC OCEAN

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PREFACE

The Tuna and Billfish Assessment Programme is an externally funded part of the work programme of the South Pacific Commission and is the successor of the Skipjack Survey and Assessment Programme. Current responsibilities of the Tuna Programme include compilation and maintenance of a fisheries statistics data base for the commercial fisheries in the region, and biological research on fish stocks which support this fishery. The work of the Programme is presently funded by donations from the governments of Australia, France, New Zealand, and the United States of America. The beneficiaries of this work are the island states of the South Pacific Commission who use the research results in the development and management of fisheries in their Exclusive Economic Zones.

The Technical Report series published by the Tuna Programme documents research results obtained by Programme staff. These reports cover a wide variety of topics and range in content from highly technical material of interest primarily to specialists, to material of much wider interest. The basis for these reports is the ongoing research of the Programme and includes information obtained by Programme staff during the pursuit of their current activities, data contained in the regional fisheries data base, and data obtained during the Skipjack Programme.

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1.0 INTRODUCTION

The successful development of pole-and-line fisheries for tuna is largely dependent on the availability of abundant and suitable bait (Kearney and Rivkin 1981; Kearney 1983). In the central and western Pacific region the abundance of bait species varies greatly (Kearney 1983). Previous studies have shown qualitative differences in fishing performance among different groups of baitfish (Hester 1974; Baldwin 1977; Smith 1977). The present study uses multivariate statistics to quantify fishing performance of six baitfish groups. The groups are baitfish from the families Engraulidae (anchovies), Clupeidae (sardines and herrings), Dussumieriidae (sprats) and Atherinidae (hardyheads), and two cultured baitfish, mollies (Poecilia mexicana) and milkfish (Chanos chanos), both of which are considered to have some potential as baitfish (chum) for pole-and-line fisheries (Gopalakrishnan 1976; Bryan 1980). The Skipjack Programme of the South Pacific Commission collected data for such comparisons with two live-bait, pole-and-line vessels of Japanese registry. The vessels were chartered between 1977 and 1980 to assess skipjack (Katsuwonus pelamis) and baitfish resources over a large part of the central and western Pacific using standardised fishing methods (Kearney 1982).

Baitfish performance may be judged on two criteria: how effectively baitfish stimulate tuna to bite the lures, and how well they survive the effects of capture and confinement in bait wells (Hester 1974). Four indices, calculated for each fishing day, were used in the present study to measure fishing effectiveness. The tuna/bait ratio (the ratio of total tuna catch in kilograms to kilograms of bait used as chum) is a commonly used index to measure baitfish fishing effectiveness (Baldwin 1980; Bryan 1980; Kearney and Rivkin 1981). The second index, chumming success, is defined as the percentage of schools chummed which responded positively, that is, at least one fish was landed by pole-and-line gear. Chumming success is one measure of the "attractiveness" of bait to the predator species. A more appropriate index of "attractiveness", at least from a fisherman's point of view, is catch in kilograms per positive school. One could view this index as the ability of a bait species to stimulate intense tuna feeding and to hold tuna within fishing range of the vessel. The fourth index, catch in kilograms per fishing day, is in effect an index which integrates over the three previous indices. With respect to survival of baitfish aboard fishing vessels, the average daily mortality of bait while held in bait tanks was used to measure how well baitfish withstood the effects of handling and confinement.

During the study period, cultured mollies and milkfish, and tropical species in the anchovy, sprat, sardine and hardyhead families dominated the bait used as chum (Table 1). Results in this study are from 466 fishing days by the Programme in tropical waters of 21 countries and territories in the South Pacific Commission area (Figure 1).

TABLE 1. KILOGRAMS OF BAIT LOADED ON THE RESEARCH VESSELS FOR FISHING IN SOUTH PACIFIC COMMISSION WATERS. The most common species that were loaded are listed in order of their abundance by weight within each group.

	Tropical anchovies	Tropical sprats	Tropical sardines	Tropical hardyheads	Other tropical species	Mollies	Milkfish	Temperate species	Total
Kilograms	27,322	8,771	18,019	2,720	7,134	1,745	2,213	3,128	71,052
Percentage	38.5%	12.3%	25.4%	3.8%	10.0%	2.5%	3.1%	4.4%	
1.	*Stolephorus devisi*	*Spratelloides delicatulus*	*Herklotsichthys quadrimaculatus*	*Hypoatherina ovalaua*	*Rastrelliger kanagurta*	*Poecilia mexicana*	*Chanos chanos*	*Sardinops neopilchardus*	
2.	*S. heterolobus*	*S. gracilis*	*Sardinella sirm*	*Atherinomorus lacunosus*	*Gymnocaesio gymnopterus*			*Trachurus sp.*	
3.	*S. indicus*	*Dussumieria sp.*	*S. marquesensis*	*H. temmincki*	*Selar crumenopthalmus*			*Scomber australasicus*	
4.	*S. buccaneeri*	*S. lewisi*	*S. clupeoides*		*Rhabdamia cypselurus*			*Sardinops melanosticta*	
5.	*Thrissina baelama*		*S. melanura*					*Engraulis japonicus*	

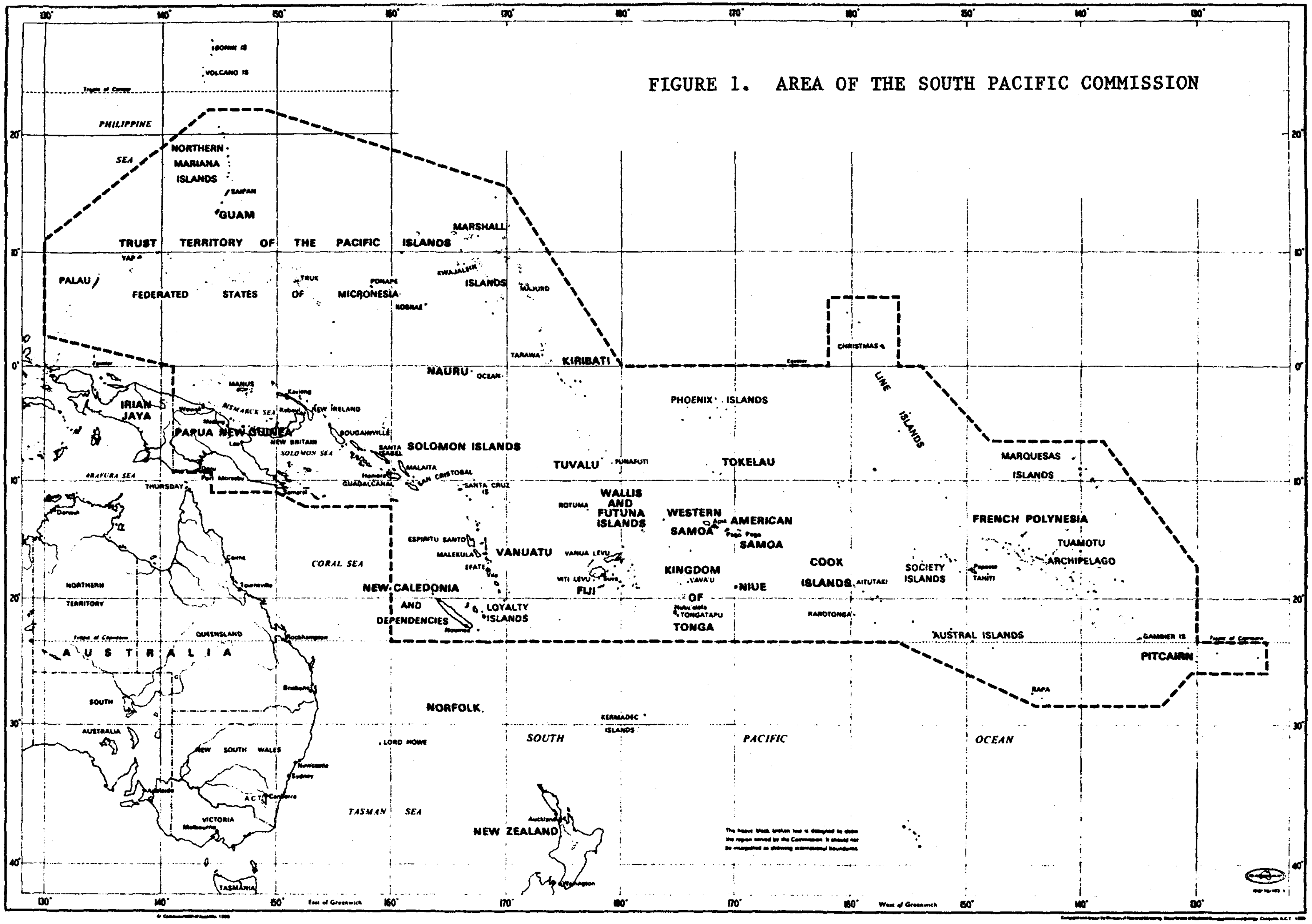

FIGURE 1. AREA OF THE SOUTH PACIFIC COMMISSION

2.0 METHODS

2.1 Sources and Preparation of Data

Fishing effectiveness indices were calculated for each of the six baitfish groups (anchovies, sardines, hardyheads, mollies, milkfish and sprats). The basic sampling unit was a day of fishing when at least one school was chummed; 432 of 466 fishing days satisfied this criterion. Further filtering of the data set was necessary, however, to isolate the days on which species in a baitfish group dominated the bait used as chum. Seventy per cent was used as the cut-off level in allocating a particular fishing day to a baitfish group, that is, 70 per cent of bait on board at the commencement of fishing belonged to one group. Due to limited data the level of cut-off for hardyheads was set at 50 per cent. A total of 241 days satisfied all the above selection criteria.

The following information was recorded on each fishing day: hours spent fishing and searching for tuna, number of schools sighted while fishing and searching, number of schools chummed, number of "positive" schools, weight of tuna caught per school, percentage species composition of the bait carried at commencement of fishing, kilograms of bait carried at commencement of fishing, kilograms of bait used as chum, kilograms of dead bait, sea condition while fishing (Beaufort scale), sea surface temperature (tenths of °C), and moon age (days after new moon). Argue (1982) and Hallier, Kearney and Gillett (1982) give details of the methods used to collect these data. Tuna catch included skipjack, yellowfin and other species (mackerel tuna, frigate tuna, etc.); however, species other than skipjack and yellowfin accounted for less than one per cent of the total catch. Skipjack accounted for approximately 90 per cent of the catch. Samples of each species were obtained from most schools fished by the research vessels (Argue 1982) and measured for fork length, weight, sex, gonad weight and stage of maturity.

Numbers of skipjack and yellowfin were converted to total weight caught for each school using average fork length for each species and school and a length-weight relationship appropriate to each species (Tuna Programme, unpublished data). The relationships used were:

$$Ws = 0.9049E\text{-}5\ Ls^{3.2108}$$

$$Wy = 0.2009E\text{-}4\ Ly^{2.9882}$$

where Ls and Ly are the fork lengths of skipjack and yellowfin respectively, and Ws and Wy are estimated round weights in kilograms for these species. The estimated weights were multiplied by the number caught in each school to give weight caught for each school. For each day, estimates of the weight of skipjack and yellowfin caught were found by summing over weights for all schools fished. Species other than skipjack and yellowfin were assumed to weigh 2.5 kg each.

For fishing effectiveness analyses the sample sizes for each baitfish group were: anchovies 107 days, sardines 37 days, hardyheads 15 days, mollies 17 days, milkfish 20 days, and sprats 45 days. Samples were widely distributed amongst countries and territories in the study area (Table 2).

TABLE 2. DISTRIBUTION OF BAIT SAMPLES AMONGST GEOGRAPHICAL GROUPS OF COUNTRIES AND TERRITORIES IN TROPICAL WATERS. Grouping of countries and territories based on surface oceanographic and geographic features, from Argue, Conand and Whyman (1983).

Group No.	Countries and Territories	Surface Oceanographic and Geographic Features*	Anchovies	Sardines	Hardy-heads	Mollies	Milkfish	Sprats
1	Papua New Guinea Solomon Islands Vanuatu	Water temperature high; salinity low; large, high land masses; South Equatorial Current	50(37)**	4(1)	3(2)	-	-	2(2)
2	American Samoa Western Samoa Fiji Niue Wallis and Futuna Islands Tonga	Water temperature high; salinity moderate; high islands; South Equatorial Current	26(9)	4(2)	3(1)	7(6)	-	11(4)
3	Southern Cook Islands Society Islands Tuamotu Islands	Water temperature high; salinity high; mostly small islands and atolls; South Equatorial Current	-	2(1)	-	4(4)	8(7)	10(5)
4	Marquesas Islands	Water temperature high; salinity high; small islands (some high)	-	24(6)	-	-	5(5)	-
5	Federated States of Micronesia Marshall Islands Northern Mariana Islands Palau	Water temperature high; salinity low; mixture of small islands (some high) and atolls; North Equatorial Countercurrent	22(11)	1(1)	9(9)	-	-	6(2)
6	Kiribati Nauru Tokelau Tuvalu Northern Cook Islands	Water temperature moderate; salinity high; atolls; equatorial upwelling region	-	2	-	6(6)	3(2)	14(6)
7	Queensland New Caledonia	Strong seasonal variation in water temperature; salinity high; large land mass; Coral Sea	9(3)	-	-	-	-	2(1)
8	Gambier Islands Pitcairn Islands	Strong seasonal variation in water temperature; salinity moderate; small islands	-	-	-	-	4(4)	-
		Total	107(60)	37(11)	15(12)	17(16)	20(18)	45(20)

* Average annual water temperature high...........~28.0°C to 30.0°C
Average annual water temperature moderate.......~25.0°C to 27.9°C
Average annual surface salinity high............greater than ~35.5%
Average annual surface salinity moderate........~34.5% to 35.5%
Average annual surface salinity low.............less than ~34.5%

** Sample sizes for baitfish mortality analysis in brackets.

In the study of baitfish mortality the above data sets were used, but only for those days on which some bait survived until the end of the day, since baitfish mortality, M, was estimated, for a 24-hour period, on the proportion of bait that survived to the end of that period. Instantaneous mortality was calculated as follows:

$$M = \left[-\ln \frac{(BCAR-MORT-USE)}{BCAR} \right] \left(\frac{MORT}{BCAR} \right)$$

where BCAR = kilograms of bait alive at the beginning of the day

MORT = kilograms of bait dying each day prior to being chummed

USE = kilograms of bait used as chum each day.

Sample sizes for mortality comparisons were: anchovies 60 days, sardines 11 days, hardyheads 12 days, mollies 16 days, milkfish 18 days, and sprats 20 days (Table 2).

2.2 Factors Affecting Fishing Effectiveness and Baitfish Mortality

Catches of tuna by the pole-and-line method may be affected by many variables including environmental factors such as sea surface temperature, sea condition, moon phase; biological factors such as abundance of tuna and their stage of sexual maturity, species of bait used; and operational factors such as the amount of bait available and the chumming strategy. The Programme obtained measures for several of these factors on each fishing day.

In the case of water temperature, the value assigned to any fishing day was the average of 0900 hour and 1500 hour measurements of sea surface temperature. Sea condition was measured by the average of Beaufort scale recordings at 0900 hours and 1500 hours. Moon age was included on the basis of work by Kearney (1977), who suggested that moon age had a direct effect on pole-and-line catches. Moon age was measured on a daily scale from 1 to 14, where 14 was full moon.

An independent estimate of tuna abundance unfortunately was not available. One possible estimate of tuna abundance, number of tuna schools sighted per hour spent fishing and searching, was found to be inversely correlated with time spent fishing, since fishing and searching time were not separated. Thus, when fishing was productive, more time was spent catching fish and fewer schools were sighted. Due to this relationship the number of tuna schools sighted per hour could not be used as an index of fish abundance. Another possible index of tuna abundance, catch per fishing day for Japanese pole-and-line vessels, was available in the areas the Programme fished, but for only some of the Programme's fishing days. Each fishing day that fell in a quarterly 5° latitude/longitude cell containing Japanese catch and effort data was assigned the Japanese catch-per-unit-effort (CPUE) for that cell as a measure of tuna abundance.

The responses of some temperate fish species to fishing lures has been associated with their degree of sexual maturity (Homans and Vladykov 1954; Argue 1970). The very low incidence of skipjack in late stages of maturity in the Programme's pole-and-line catches was also suggestive that catchability might vary with maturity. Female skipjack gonad indices (Schaefer and Orange 1956) were assigned to fishing days for which there were sufficient samples.

With respect to factors which may affect baitfish mortality, sea condition, amount of bait carried and sea surface temperature were expected to have an influence on daily mortality. The amount of handling to which baitfish were exposed during fishing operations was included as a fourth factor, and was estimated by bait chummed as a percentage of bait carried at the beginning of the day.

2.3 Analytical Methods

The factors in Section 2.2 were treated as independent variables in stepwise analyses of covariance to determine whether fishing performance indices differed significantly amongst baitfish groups. Baitfish groups were included in the analyses as qualitative factors. In Table 3, dependent and independent variables for each analysis are summarised. Percentage chumming success, one of four fishing effectiveness indices, was omitted from analysis of covariance since its daily measurement was generally based on fewer than ten schools.

Correlations between all possible pairs of variables, both dependent and independent, were examined for possible collinearity within the total data set used for fishing effectiveness comparisons (241 fishing days). Excluding tuna/bait ratio, three of the four fishing effectiveness indices were the only variables highly correlated with each other (correlation coefficients all positive and in the range 0.88 to 0.97); all other variables were statistically independent. None of the dependent variables was highly correlated with any one independent variable, suggesting that several variables were required to describe variation in the dependent variables and/or continuous variables may have had different relationships to dependent variables according to which type of bait was used.

All the dependent variables, including bait carried, had markedly heteroscedastic and non-normal distributions. Dependent variables having such properties should not be used in an untransformed state in normal theory, linear models. In addition, homoscedasticity and normality in independent variables contributes to the robustness of significance tests in linear models and is therefore desirable (Seber 1973).

For each independent variable, ordered scaled residuals were plotted against normal ordered statistics. Only bait carried was found to differ markedly from a normal distribution and the natural logarithm of bait carried (kg+1) was found to be approximately normally distributed.

The Box-Cox algorithm (Box and Cox 1964; Stuart 1980) was used to suggest a suitable transformation on each of the dependent variables, under conditions of an assumed approximate model for the data. The model assumed included all likely independent variables, transformed where necessary. For the dependent variables (Y), a power transformation $Y'=(Y^{\lambda}-1)/\lambda$

TABLE 3. DEPENDENT AND INDEPENDENT VARIABLES FOR STATISTICAL ANALYSES

	Dependent Variable	Independent Variables						
i	Y_i	X_1	X_2	X_3	X_4	X_5	X_6	X_7
1	Catch per day	Baitfish group	Bait carried	Sea condition	Moon age	SST	Gonad index	Tuna abundance
2	Catch per positive school	Baitfish group	Bait carried	Sea condition	Moon age	SST	Gonad index	
3	Tuna/bait ratio	Baitfish group	Bait carried	Sea condition	Moon age	SST	Gonad index	
4	Daily baitfish mortality	Baitfish group	Bait carried	Sea condition	Moon age	SST	Gonad index	Bait handling

Baitfish Groups

1. Anchovies 2. Sardines 3. Hardyheads 4. Mollies 5. Milkfish 6. Sprats

with λ in the range 0.2 to 0.4, was indicated. The value λ =0.3333 therefore was chosen for the transformation.

Following preliminary examination and transformation of the data, the general linear model analysis package (GLIM) (Baker and Nelder 1978) was used to perform a stepwise linear analysis of covariance for each of the sets of fishing effectiveness data, and for the set of baitfish mortality data. In all analyses, baitfish groups were treated as qualitative factors, called "factors" in the terminology of Baker and Nelder (1978). The other independent variables were entered crossed with baitfish groups since preliminary analyses indicated that, in most cases, the independent variables had differing effects on the dependent variables, according to which baitfish group was used. For example, catch was positively correlated with sea condition for certain baitfish groups but was negatively correlated with sea condition for other baitfish groups. Addition of independent variables to the (forward) stepwise analysis was stopped when an F-test-statistic based on the residual sums of squares from fitting successive models was not significant at the five per cent level. At this stage of the model selection procedure, the types of models being considered were of the form:

(1) $y' = A + B_i X_1 + C_i X_2 + ...$

(2) $y' = A + A'_i + B_i X_1 + C_i X_2 + ...$

where y' is the (transformed) dependent variable, e.g. catch, catch per day, etc.;
A is the intercept parameter
A'_i is the parameter representing bait as a factor
B_i, C_i, etc. are coefficient parameters for the continuous variables X_1, X_2, etc. in the model, and
$i = 1,2, ... 6$ are coefficients for the six baitfish groups.

The difference between Equations (1) and (2) is that Equation (1) has a single intercept on the y axis, A, whereas Equation (2) has an intercept for each baitfish group, $A + A'_i$. In Equation (2), bait, as a factor, enters the model in its own right.

After selection of significant factors, further F-tests were performed to determine whether crossing each independent variable with a baitfish group gave significantly improved results over models using uncrossed variables. In no case was the use of uncrossed variables sufficient. Had there been cases where no significant improvement was indicated by the use of crossed variables, the uncrossed variable would have been accepted as this required fitting of one parameter instead of six parameters in the case of variables crossed with baitfish groups. At this stage of model selection, the types of models being considered are of similar form to Equations (1) and (2) except that B_i, C_i, etc. terms are replaced by unsubscripted terms B, C, etc. which are constant across bait types.

(3) $y' = A + B X_1 + C X_2 + ...$

(4) $y' = A + A'_i + B X_1 + C X_2 + ...$

Equation (3) is the single intercept model and Equation (4) the multiple intercept form. These models are analogous to sets of simple linear regression models in which slopes are parallel, although intercepts may vary.

Two residual plots were used to check the adequacy of the final models and the normality of the (transformed) dependent variables, viz. a plot of scaled residuals versus fitted values and a plot of ordered scaled residuals versus normal ordered statistics. Such plots also enabled identification of outliers in the data.

The final fitted models, called full models, were used to calculate predicted values of the dependent variables, given baitfish groups and values of the independent variables specifying a standard set of field conditions. Confidence intervals for expected values of a dependent variable, given a set of independent variable values, were constructed from the variance-covariance matrix of the predicted variables, using appropriate values of Student's t-statistic (Kendall and Stuart 1977).

3.0 RESULTS

Values of the dependent and independent variables for all daily samples in each baitfish group are listed in the Appendix. The Appendix also contains variable means, standard deviations and ranges, calculated on untransformed values for each baitfish group.

3.1 Adequacy of Models and Exclusion of Outliers

One group of 24 days fished in Papua New Guinea at the commencement of field work was excluded from analyses becauses catches were abnormally low (Tuna Programme 1984) and were considered unrepresentative of the fishing performance of the Programme vessels. Plots of scaled residuals versus fitted values for an assumed approximate model for the remaining data showed that four additional days were outliers; no catch was taken on three of these days, although all conditions indicated that good catches should have been possible, so these days were excluded from the analyses.

3.2 Fishing Effectiveness

There were only 62 days for which there was a measure of tuna abundance (mostly skipjack). Of these days, nearly half (28 days) were days on which anchovies were used as bait, the remaining 24 days being divided among the other 5 bait types. A stepwise linear regression was performed for the 28 days using anchovies, but the abundance index had not entered the regression at the stage at which all significant variables had entered (two variables in this case). These results are considered inconclusive since so few points were available and since Japanese pole-and-line CPUE is a very indirect measure of abundance experienced by Skipjack Programme vessels.

Female skipjack gonad indices could be calculated for 166 of the 241 days. The analysis of covariance for these days used skipjack catch per day as the dependent variable, and independent variables X_1 to X_6 (female skipjack gonad index). Skipjack gonad index did not reduce the sum of squares sufficiently to be included in the analysis. When the data set was restricted to 62 days when anchovies were used as bait, skipjack maturity entered at step three, after bait carried and moon age, and reduced the sum of squares by six per cent. Skipjack gonad index was excluded as an independent variable from remaining analyses because it was not significant in the analysis of the larger data set.

In Table 4, results are presented of the analysis of covariance comparing catch per fishing day amongst baitfish groups, using baitfish group, bait carried, sea condition, moon age and sea surface temperature as independent variables, each crossed with bait type. The order that independent variables entered the analysis was: bait carried, sea condition, sea surface temperature and moon age, and the full model accounted for 46.7 per cent of the total variation in catch per day. Bait as a factor did not significantly reduce the sum of squares, thus giving the single intercept form of model as shown in Equation (1). The full model used parameters for bait carried, sea condition, moon age and sea surface temperature for each baitfish group. The improvement in fit was statistically significant in the case of addition of each variable. Catch per day varied inversely with sea surface temperature, and varied directly with bait carried, for each baitfish group except milkfish. Sea condition was negatively correlated with catch per day for each baitfish group except sardines. Moon age and catch per day were sometimes positively correlated, sometimes negatively correlated depending upon the baitfish species.

Results of the analysis of covariance comparing catch per positive school amongst baitfish groups, using the same independent variables as those used for catch per day, are given in Table 5. Bait carried entered the analysis first, followed by sea condition, sea surface temperature and moon age. The full model required separate curves for each baitfish group for each independent variable. The signs of coefficients for relationships between dependent and independent variables were identical to those described for catch per day. The full model accounted for only 35.4 per cent of the total variation in catch per positive school.

The results of the analysis of covariance comparing tuna/bait ratio amongst baitfish groups are given in Table 6. In this analysis only 31.2 per cent of the total variation were accounted for by the independent variables. Sea condition entered the analysis first, followed by sea surface temperature, moon age and bait carried. The full model required different coefficients for independent variables for each baitfish group. Sea condition was negatively related to the tuna/bait ratio for all baitfish; the other three independent variables had either negative or positive signs for their coefficients, depending on the baitfish group.

In Table 7, mean rates of chumming success for each baitfish group are presented. Chumming success was calculated as the percentage of all schools chummed (summed over days) that responded positively to chumming. The last two columns present chumming success and 95 per cent binomial confidence intervals for each baitfish group. Hardyhead chumming success was 27.3 per cent, whereas chumming success for the other baitfish groups was in the range from 46.7 per cent to 62.5 per cent. Except for hardyheads, confidence intervals for all groups overlap.

TABLE 4. RESULTS OF ANALYSIS OF COVARIANCE FOR CATCH PER DAY, USING TRANSFORMED VARIABLES WHERE APPROPRIATE.

Model: $(\hat{Y}^{.3333}-1)/.3333 = A+B_iX_2+C_iX_3+D_iX_5+E_iX_4)$ where A, B_i, C_i, D_i, E_i, for baitfish groups, i=1,....,6 are parameters of the model, X_2 is (transformed) quantity of bait carried, X_3 is sea condition, X_5 is sea surface temperature, X_4 is (transformed) moon phase, and $\hat{Y}$ is predicted catch.

	Parameter	Estimate	Standard Error of Estimate
	A	92.85	30.34
Bait carried	B_1	12.43	1.76
	B_2	5.58	2.09
	B_3	6.93	4.04
	B_4	4.78	3.65
	B_5	-0.0792	3.22
	B_6	4.75	1.91
Sea condition	C_1	-5.61	1.24
	C_2	2.63	1.50
	C_3	-2.74	2.62
	C_4	-5.79	3.41
	C_5	-1.31	2.35
	C_6	-1.60	1.72
Sea surface temperature	D_1	-4.27	1.01
	D_2	-3.59	1.14
	D_3	-3.98	1.30
	D_4	-2.54	1.25
	D_5	-1.85	1.10
	D_6	-3.03	1.07
Moon phase	E_1	0.550	0.361
	E_2	-0.105	0.477
	E_3	1.306	1.26
	E_4	-1.230	0.925
	E_5	-1.768	0.629
	E_6	-1.119	0.521

TABLE 5. RESULTS OF ANALYSIS OF COVARIANCE FOR CATCH PER POSITIVE SCHOOL, USING TRANSFORMED VARIABLES WHERE APPROPRIATE.

Model: $(\hat{Y}^{.3333}-1)/.3333 = A+B_i X_2+C_i X_3+D_i X_5+E_i X_4)$ where A, B_i, C_i, D_i, E_i, X_2, X_3, X_5, X_4 are as given in Table 4 and $\hat{Y}$ is predicted catch per positive school.

	Parameter	Estimate	Standard Error of Estimate
	A	69.06	24.46
Bait carried	B_1	7.76	1.42
	B_2	1.33	1.68
	B_3	6.59	3.26
	B_4	2.42	2.95
	B_5	-0.514	2.60
	B_6	3.08	1.54
Sea condition	C_1	-3.09	1.00
	C_2	1.91	1.21
	C_3	-2.55	2.11
	C_4	-3.48	2.75
	C_5	-0.078	1.89
	C_6	-2.00	1.38
Sea surface temperature	D_1	-3.08	0.810
	D_2	-2.10	0.919
	D_3	-3.19	1.05
	D_4	-1.88	1.01
	D_5	-1.58	0.884
	D_6	-2.09	0.862
Moon phase	E_1	0.576	0.291
	E_2	-0.405	0.385
	E_3	1.44	1.02
	E_4	-0.715	0.746
	E_5	-0.815	0.507
	E_6	-0.760	0.420

TABLE 6. RESULTS OF ANALYSIS OF COVARIANCE FOR TUNA/BAIT RATIO.

Model: $(Y^{.3333}-1)/.3333 = A+B_iX_3+C_iX_5+D_iX_4+E_iX_2$ where A, B_i, C_i, D_i, E_i, X_3, X_5, X_4, X_2 are as given in Table 4 and Y is tuna/bait ratio.

	Parameter	Estimate	Standard Error of Estimate
	A	21.26	6.31
Sea condition	B_1	-1.16	0.259
	B_2	0.333	0.312
	B_3	-0.478	0.545
	B_4	-1.46	0.710
	B_5	-0.449	0.488
	B_6	-0.483	0.357
Sea surface temperature	C_1	-0.751	0.209
	C_2	-0.609	0.237
	C_3	-1.02	0.271
	C_4	-0.530	0.260
	C_5	-0.545	0.228
	C_6	-0.592	0.223
Moon phase	D_1	0.072	0.075
	D_2	0.017	0.099
	D_3	0.387	0.263
	D_4	-0.457	0.192
	D_5	-0.249	0.131
	D_6	-0.199	0.109
Bait carried	E_1	0.979	0.366
	E_2	-0.407	0.434
	E_3	1.60	0.840
	E_4	0.933	0.760
	E_5	0.021	0.670
	E_6	0.024	0.398

TABLE 7. CHUMMING SUCCESS FOR EACH BAITFISH GROUP

Baitfish Group	Sample Size (Days)	Schools Chummed	Positive Schools	Percentage Positive Schools	(S.D.)
Anchovies	81	398	217	54.5	(5.0)
Sardines	37	176	110	62.5	(7.2)
Hardyheads	14	55	15	27.3	(6.0)
Mollies	17	94	45	47.9	(10.1)
Milkfish	20	111	56	50.5	(9.3)
Sprats	45	167	78	46.7	(7.6)

TABLE 8. RESULTS OF ANALYSIS OF COVARIANCE FOR BAITFISH MORTALITY, USING TRANSFORMED VARIABLES WHERE APPROPRIATE.

Model: $(Y^{.3333}-1)/.3333 = A+B_i+C_iX_3+D_iX_2$ where A, B_i, C_i, D_i, X_3, X_2 are as described in Table 4.

	Parameter	Estimate	Standard Error of Estimate
	A	-3.68	0.693
Baitfish group	B_2	2.61	1.85
	B_3	3.07	1.28
	B_4	3.89	2.07
	B_5	4.80	1.78
	B_6	4.58	1.29
Sea condition	C_1	0.202	0.082
	C_2	0.016	0.224
	C_3	-0.171	0.151
	C_4	-0.144	0.194
	C_5	0.063	0.141
	C_6	0.069	0.195
Bait carried	D_1	0.405	0.131
	D_2	0.010	0.276
	D_3	-0.043	0.183
	D_4	-0.343	0.343
	D_5	-0.581	0.276
	D_6	-0.448	0.181

3.3 Baitfish Mortality

The results of the analysis of covariance for differences in average daily mortality amongst baitfish groups are presented in Table 8. The bait handling factor did not significantly reduce the sum of squares and was not included in the full model. Sea condition, followed by bait carried, and baitfish group as a factor, were included, in this order, as three factors in the full model. This model was of the form of Equation (2), having a different intercept for each baitfish group. Collectively, they accounted for 44.2 per cent of the variation in the sum of squares for daily baitfish mortality. The model included separate curves for sea condition and bait carried for each baitfish group; the signs for coefficients were sometimes negative, sometimes positive for the independent variables.

3.4 Standardised Values for Dependent Variables

Standardised values for catch per day (Table 9), catch per positive school (Table 10), tuna/bait ratio (Table 11) and baitfish mortality (Table 12) were calculated for each baitfish group using the parameters for the respective full models in Tables 4, 5, 6 and 8, and various levels of the independent variables. The top four rows of column (1) in Tables 9 to 11 and the top two rows of column (1) in Table 12 are "average conditions" for independent variables, obtained by inspecting the frequency distributions for each independent variable and baitfish group for values that were close to the median within each baitfish group. The top four rows (in Tables 9 to 11 and top two rows in Table 12) of columns (2) to (5) contain high and low values for the two independent variables that accounted for most of the variability of each dependent variable. In each column, from (2) to (5), one individual variable is changed. For example, in Table 9, column (2), the value was set to the minimum bait carried, averaged over all species, then in column (3), it was set to the averaged maximum bait carried. Similarly, in column (4) the sea condition variable was set to an averaged value corresponding to calm conditions, and in column (5) it was set to a value corresponding to averaged rough conditions. Note that transformed and untransformed values are given for bait carried. Ranges for independent variables were chosen so that they included, or were very close to the range of values for each baitfish group. Column (6) presents unadjusted means for the points included in the analyses of covariance.

Values for dependent variables in each column in Tables 9 to 12 were ranked from one to six, where one corresponds to the most favourable or numerically highest standardised value (except baitfish mortality where rank one corresponds to lowest mortality rate). Ranking of fishing effectiveness indices (catch per day, catch per positive school, tuna/bait ratio, and chumming success) and baitfish mortality, for each baitfish group are summarised in Table 13. Ranks in the table are for "average conditions", and for the average of fishing effectiveness indices under variable conditions, except chumming success where only one series of ranks is given corresponding to the values for percentage chumming success in Table 7.

TABLE 9. STANDARDISED CATCH PER DAY FOR AVERAGE CONDITIONS OF THE INDEPENDENT VARIABLES AND FOR HIGH AND LOW VALUES OF BAIT CARRIED AND OF SEA CONDITION. The 95 per cent confidence interval for each catch per day estimate is given below the estimate.

Independent variables	Average Conditions	Low Bait Carried	High Bait Carried	Calm Seas	Rough Seas
Bait carried	5.5 (245 kg)	3.75 (43 kg)	6.5 (665 kg)	5.5	5.5
Sea condition	3.0	3.0	3.0	0.5	4.0
Moon age	7 days	7 days	7 days	7 days	7 days
Sea temperature	28.5°C	28.5°C	28.5°C	28.5°C	28.5°C

	Catch per day estimate (kg) (95% confidence interval)					
Bait (sample size)	Average Conditions	Low Bait Carried	High Bait Carried	Calm Seas	Rough Seas	Unadjusted Means
Anchovies (81)	965	18	2759	3086	514	1790
	707-1279	0-102	1894-3854	2026-4464	281-854	
Sardines (37)	1135	370	1856	559	1446	1399
	746-1638	111-870	1029-3037	140-1434	943-2101	
Hardyheads (14)	369	31	854	847	246	270
	39-1318	0-226	41-3758	113-2792	4-1306	
Mollies (17)	501	137	866	2083	217	726
	111-1357	0-1270	213-2244	506-5427	2-1220	
Milkfish (20)	691	702	685	980	594	1208
	341-1224	81-2429	265-1409	194-2792	207-1291	
Sprats (45)	455	119	799	735	367	775
	196-879	31-299	266-1782	240-1657	102-900	

TABLE 10. STANDARDISED CATCH PER POSITIVE SCHOOL PER DAY FOR AVERAGE CONDITIONS OF THE INDEPENDENT VARIABLES AND FOR HIGH AND LOW VALUES OF BAIT CARRIED AND OF SEA CONDITION. The 95 per cent confidence interval for each catch per day estimate is given below the estimate.

Independent variables	Average Conditions	Low Bait Carried	High Bait Carried	Calm Seas	Rough Seas
Bait carried	5.5 (245 kg)	3.75 (43 kg)	6.5 (665 kg)	5.5	5.5
Sea condition	3.0	3.0	3.0	0.5	4.0
Moon age	7 days	7 days	7 days	7 days	7 days
Sea temperature	28.5°C	28.5°C	28.5°C	28.5°C	28.5°C

		Catch per positive school per day (kg) (95% confidence interval)				
Bait (sample size)	Average Conditions	Low Bait Carried	High Bait Carried	Calm Seas	Rough Seas	Unadjusted Means
Anchovies (81)	374 265-510	19 1-81	939 605-1376	936 561-1450	235 124-399	668
Sardines (37)	418 260-630	301 110-638	497 233-909	204 41-580	534 329-810	471
Hardyheads (14)	290 45-906	21 0-137	686 61-2573	669 127-1940	192 8-866	252
Mollies (17)	163 25-508	66 0-64	246 39-763	585 91-1831	79 0-525	274
Milkfish (20)	228 98-440	263 20-1024	209 64-487	235 23-861	225 68-528	431
Sprats (45)	218 91-429	76 22-181	350 107-815	454 160-986	154 37-399	459

TABLE 11. STANDARDISED TUNA/BAIT RATIO FOR AVERAGE CONDITIONS OF THE INDEPENDENT VARIABLES AND FOR HIGH AND LOW VALUES OF SEA SURFACE TEMPERATURE AND OF SEA CONDITION. The 95 per cent confidence interval for each tuna/bait ratio estimate is given below the estimate.

Independent variables	Average Conditions	Low Sea Surface Temp.	High Sea Surface Temp.	Calm Seas	Rough Seas
Bait carried	5.5 (245 kg)	5.5	5.5	5.5	5.5
Sea condition	3.0	3.0	3.0	0.5	4.0
Moon age	7 days	7 days	7 days	7 days	7 days
Sea temperature	28.5°C	27.0°C	30.0°C	28.5°C	28.5°C

		Tuna/bait ratio (95% confidence interval)				
Bait (sample size)	Average Conditions	Low Sea Surface Temp.	High Sea Surface Temp.	Calm Seas	Rough Seas	Unadjusted Means
Anchovies (81)	5.4	9.7	2.6	20.2	2.6	11.9
	3.7-7.5	6.1-14.4	1.4-4.5	12.6-30.3	1.2-4.7	
Sardines (37)	7.1	11.1	4.2	4.5	8.4	8.3
	4.4-10.8	6.4-17.7	2.0-7.7	1.0-11.8	5.1-12.9	
Hardyheads (14)	5.8	12.2	2.1	10.5	4.4	4.5
	1.0-17.2	2.4-34.6	0.2-7.6	1.9-31.3	0.3-17.7	
Mollies (17)	11.2	15.6	7.6	41.2	5.3	11.5
	4.0-24.0	6.1-31.9	1.9-19.6	14.8-88.3	0.5-20.1	
Milkfish (20)	7.1	10.5	4.5	12.1	5.5	13.9
	3.6-12.3	5.8-17.2	1.5-9.8	2.9-31.4	2.0-12.0	
Sprats (45)	3.8	6.4	2.0	7.6	2.8	10.3
	1.6-7.5	2.6-12.8	0.6-4.8	2.6-16.6	0.7-7.1	

TABLE 12. STANDARDISED INSTANTANEOUS DAILY BAITFISH MORTALITY FOR AVERAGE CONDITIONS OF THE INDEPENDENT VARIABLES AND FOR LOW AND HIGH VALUES OF SEA CONDITIONS AND OF BAIT CARRIED. The 95 per cent confidence interval for each daily estimate is given below the estimate.

Independent variables	Average Conditions	Calm Seas	Rough Seas	Low Bait Carried	High Bait Carried
Bait carried	5.5 (245 kg)	5.5	5.5	3.75 (43 kg)	6.5 (665 kg)
Sea condition	3.0	0.5	4.0	3.0	3.0

Bait (sample size)	Average Conditions	Calm Seas	Rough Seas	Low Bait Carried	High Bait Carried	Unadjusted Mean
	Instantaneous daily baitfish mortality (95% confidence interval)					
Anchovies (60)	0.3711 0.2789-0.4819	0.1668 0.0777-0.3067	0.4854 0.3243-0.6926	0.1124 0.0348-0.2609	0.6217 0.4042-0.9060	0.4469
Sardines (11)	0.3169 0.1481-0.5808	0.2981 0.0197-1.2122	0.3246 0.1083-0.7236	0.3085 0.0197-1.2636	0.3217 0.1300-0.6446	0.5339
Hardyheads (12)	0.1646 0.0575-0.3581	0.3294 0.0966-0.7867	0.1184 0.0195-0.3622	0.1884 0.0568-0.4428	0.1519 0.0240-0.4721	0.3100
Mollies (16)	0.0269 0.0043-0.0830	0.0737 0.0022-0.3558	0.0160 0.0000-0.1059	0.1246 0.0000-0.4030	0.0064 0.0000-0.0599	0.0438
Milkfish (18)	0.0515 0.0141-0.1268	0.0326 0.0001-0.2016	0.0608 0.0130-0.1675	0.3595 0.0293-1.3815	0.0057 0.0000-0.0362	0.0490
Sprats (20)	0.1657 0.0587-0.3577	0.1190 0.0161-0.3913	0.1873 0.0291-0.5859	0.5325 0.2375-1.0053	0.0640 0.0040-0.2632	0.3075

TABLE 13. RANKS FOR STANDARDISED FISHING PERFORMANCE INDICES UNDER AVERAGE CONDITIONS OF INDEPENDENT VARIABLES, AND FOR THE AVERAGE OF INDICES UNDER EXTREME CONDITIONS FOR INDEPENDENT VARIABLES (in brackets). The rank of one (1) is the most favourable result.

	Fishing Effectiveness Indices				
Bait	Catch/day	Catch/positive school	Tuna/bait ratio	Chumming success	Baitfish mortality
Anchovies	2 (1)	2 (1)	5 (5)	2	6 (5)
Sardines	1 (1)	1 (2)	2 (3)	1	5 (6)
Hardyheads	6 (5)	3 (3)	4 (4)	6	3 (3)
Mollies	4 (4)	6 (6)	1 (1)	4	1 (1)
Milkfish	3 (3)	4 (4)	2 (2)	3	2 (2)
Sprats	5 (5)	5 (4)	6 (6)	5	4 (3)

Numerical values for the standardised estimates fluctuate considerably, depending on the level chosen for independent variables; in almost all cases they have overlapping confidence intervals. In contrast, the ordering of these estimates amongst baitfish groups changes little with varying levels for independent variables. For example, anchovies and sardines generally had highest values for catch per day and catch per positive school, followed by sprats, milkfish, mollies and hardyheads. On the other hand, mollies and milkfish had highest values for tuna/bait ratio, followed by sardines, anchovies, sprats and hardyheads.

Numerical estimates of baitfish mortality were generally low (<0.10) for mollies and milkfish under all levels of the independent variables. Sprats and hardyheads had intermediate daily mortality rates, and the highest mortality rates were exhibited by sardines and anchovies.

4.0 DISCUSSION AND CONCLUSIONS

The two Japanese live-bait, pole-and-line vessels chartered by the Skipjack Programme operated in the waters of every country and territory in the area of the South Pacific Commission, under a variety of fishing conditions that are thought to influence the performance of baitfish. The baitfish groups that were compared in the present study, anchovies, sardines, hardyheads, mollies, milkfish and sprats, were each used over a large part of this area. Performance of baitfish was considered to be divided into two components: firstly, fishing effectiveness, measured by catch in kilograms per day, by catch per positive school per day and by the daily ratio of catch in kilograms divided by kilograms of bait chummed (tuna/bait ratio); and secondly, the ability of baitfish to survive the effects of capture and handling as measured by the average daily instantaneous mortality of baitfish, exclusive of bait chummed. Fishing performance indices were adjusted for independent variables that bore a statistical relationship to the dependent variables (bait carried at commencement of fishing, sea condition, moon age, sea surface temperature and the bait species used).

4.1 Factors Affecting Performance Indices

Table 14 presents, for the six baitfish groups, the variables that were significant in the statistical analyses, the order they entered each analysis (an indication of their relative importance in accounting for total variation), and the signs of their coefficients in the fitted models. The proportion of the total variation accounted for by each full model is shown at the bottom of each column.

In general, the results of all analyses of covariance may be taken to indicate that all independent variables have different effects upon fishing effectiveness for the different baitfish used. Regression coefficients for each of the independent variables were crossed with bait species, although a common intercept or elevation was indicated for all groups. Thus, we conclude that fishing effectiveness differed significantly among baitfish groups.

The amount of bait carried was the most important factor influencing the tuna catch per day and tuna catch per positive school. Such a result is not surprising since better catches are possible if more bait is carried.

The second most important independent variable was sea condition, based on the order sea condition entered the stepwise analyses of covariance for catch per day and catch per positive school. Sea condition entered first in the full model for the tuna/bait ratio. Positive relationships were observed between each fishing effectiveness index and sea conditions for days when sardines were used. In comparison, fishing effectiveness dropped with worsening sea conditions (higher Beaufort measures) for remaining baitfish groups, i.e. the smaller baitfish species. Small baitfish were often carried well away from the vessel in moderate winds, and they were not as adept at swimming back to the vessel as were the larger sardines. In our experience, mollies had the greatest difficulty returning to the vessel under heavy sea conditions (see also Vergne, Bryan and Broadhead 1978).

Anchovy and hardyhead indices were positively related to moon age; mollies, milkfish and sprats, on the other hand, had negative relationships with moon age. Kearney (1977) observed an apparent independent effect of the moon on tuna/bait ratios, but did not postulate a mechanism. Since the direction of the relationships between moon age and fishing effectiveness varied amongst the bait groups in this study, the writers, too, are reluctant to postulate a mechanism.

Sea surface temperature bore a consistent negative relationship to the indices of fishing effectiveness. This result is consistent with results reviewed by Forsbergh (1980) which suggested that skipjack catches dropped off at water temperatures above 28°C. Most fishing by the Programme in tropical waters was at surface temperatures between 27°C and 30°C.

TABLE 14. SUMMARY OF THE ORDER INDEPENDENT VARIABLES WERE ENTERED, THE SIGN OF COEFFICIENTS FOR EACH BAIT GROUP (group number in brackets), AND THE PROPORTION OF TOTAL VARIATION EXPLAINED BY EACH ANALYSIS OF COVARIANCE FOR EACH INDEX OF FISHING EFFECTIVENESS AND FOR BAITFISH MORTALITY

	Fishing Effectiveness						Baitfish Mortality	
	Catch/day		Catch/positive school		Tuna/bait ratio			
Independent Variables	Order entered	Signs of coefficients	Order entered	Signs of coefficients	Order entered	Signs of coefficients	Order entered	Signs of coefficients
Bait as a factor (X_1)	-		-		-		1	All +
Bait carried (X_2)	1	+(1,2,3,4,6) -(5)	1	+(1,2,3,4,6) -(5)	4	+(1,3,4,5,6) -(2)	3	+(1,2) -(3,4,5,6)
Sea condition (X_3)	2	+(2) -(1,3,4,5,6)	2	+(2) -(1,3,4,5,6)	1	+(2) -(1,3,4,5,6)	2	+(1,2,5,6) -(3,4)
Moon age (X_4)	4	+(1,3) -(2,4,5,6)	4	+(1,3) -(2,4,5,6)	3	+(1,2,3) -(4,5,6)	-	
Sea surface temp. (X_5)	3	All -	3	All -	2	All -	-	
Proportion of total variation explained (R^2)	0.4673		0.3538		0.3115		0.4422	

Note: bait 1 = anchovies
bait 2 = sardines
bait 3 = hardyheads
bait 4 = mollies
bait 5 = milkfish
bait 6 = sprats

An important result of the present study was how little of the total variability of the fishing effectiveness indices could be accounted for by the baitfish groups and the independent variables. The proportion of total variation accounted for in the analyses ranged from 46.7 per cent for catch per day to 31.2 per cent for tuna/bait ratio. A part of the unaccounted variability may have been due to daily fluctuations in tuna abundance, for which no reliable measure was available. The writers conclude that the interactions amongst baitfish, tuna, pole-and-line gear, and the environment are very complex and cannot be fully examined with observational data such as were available in the present study.

Baitfish mortality was significantly affected by bait as a factor, sea condition, and the amount of bait carried. Average daily baitfish mortality therefore differed significantly amongst baitfish groups, both with respect to their differing relationships to the independent variables and with a constant baitfish group effect. The independent variables accounted for 44.2 per cent of variability in daily baitfish mortality. The independent variable measuring bait handling during fishing operations did not enter the analysis of covariance.

Large amounts of anchovies and sardines carried in the baitwells resulted in higher mortalities. This may be the result of the conditions under which species in these groups were loaded into the baitwells. Often the Programme made large catches of anchovies and sardines. In these circumstances Smith (1977) suggested that bait be held in the net until the portion of the bait most affected by netting had died. This usually meant leaving the bait over night in the net, alongside the vessel, then loading the bait remaining alive during daylight. The Programme did not follow this procedure often, which is probably the reason for higher mortality when large quantities of these species were carried. The rate of mortality increased with decreasing amounts carried of the remaining four baitfish groups. These species were either captured in lower quantities (hardyheads, sprats) or were the cultured species (mollies and milkfish) that are known for their resistance to handling (Baldwin 1980; Bryan 1980). These four baitfish groups also were held over longer periods. The effects of confinement and handling led to an increased incidence of disease, which usually occurred when small amounts of bait remained, and which is a probable explanation for the inverse relationships between mortality and bait carried for hardyheads, mollies, milkfish and sprats.

4.2 Standardised Fishing Performance Indices

The standardised dependent variables demonstrate levels of fishing effectiveness (Tables 9 to 11) and daily baitfish mortality (Table 12) that could be achieved under average and extreme fishing conditions. Estimates of dependent variables for each baitfish group generally have overlapping confidence intervals, a reflection of the large variability in the data. At first glance, this result seems to contradict results from the analyses of covariance that showed that fishing performance differed significantly amongst baitfish groups. However, it must be remembered that analysis of covariance compares the complete curves and indicates whether there are significant differences amongst some of the curves, whereas the standardised dependent variables refer to single points on each curve. Curves for the dependent variables may approach, and even cross one another, but still remain distinct.

The baitfish groups exhibited considerable overlap in values of fishing effectiveness indices. In view of the high degree of variability in the data, we suggest that it is more appropriate to consider the rank order of the dependent variables (Table 13). Mollies ranked third lowest for catch per day and lowest for catch per positive school, but produced the highest tuna/bait ratio. Milkfish ranked just ahead of mollies for catch per day and catch per positive school, and just behind mollies for the tuna/bait ratio. This result differs from the preliminary analyses (Skipjack Programme 1980, 1981) where milkfish were more similar to sprats than to mollies and hardyheads. The preliminary analyses used unadjusted average values for dependent variables for milkfish. Our analyses took into account independent variables, which in turn reduced the standardised values of catch per day and catch per positive school for milkfish. Sprats ranked fifth for catch per day and catch per positive school, but ranked last for tuna/bait ratio. Overall, sardines and anchovies would rank most effective, followed by milkfish, mollies, sprats and then hardyheads. This would not have been the writers′ ordering of the baitfish groups had only the tuna/bait ratios been compared.

Tuna/bait ratios are heavily dependent on fishing strategy, which changes with the amount of bait carried, sea condition and proximity to productive bait grounds. The Programme used mollies and milkfish, the baitfish with the highest tuna/bait ratios, most often in circumstances where natural bait were either unavailable or difficult to obtain. Under these circumstances there is a need to conserve bait, so chummers generally were instructed to throw only enough bait to attract and keep tuna within range of the polers, and still produce reasonable catches. This added precision by the chummers tended to increase artificially the tuna/bait ratio for mollies and milkfish and thus distort its value as an index of fishing effectiveness.

Mollies and milkfish had by far the lowest rates of mortality in the bait wells, a result that, for mollies, is in keeping with the findings of Baldwin (1980). This gives these species an obvious advantage over natural bait since they can be used over longer distances, and over greater periods of time. This also brings out the issue of an overall evaluation, since on the one hand, mollies and milkfish had relatively low indices of fishing effectiveness, but on the other hand, they survived well on board the vessel. Obviously, then, there are situations where each of the baitfish groups can be used effectively, although it is questionable whether the groups that were least effective for fishing can produce consistent profitable catches.

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APPENDIX. AVERAGE VALUES, STANDARD DEVIATIONS AND RANGES FOR DEPENDENT AND INDEPENDENT VARIABLES FOR EACH BAITFISH GROUP

V A R I A B L E

Baitfish Group		Bait Carried (kg)	Bait Chummed (kg)	Sea Condition	Moon Age (adjusted)	Sea Surface Temp. (°C)	Catch (kg)	No. of Positive Schools (per day)	Catch per Positive School (kg/school)	Tuna Bait Ratio
Anchovies	Mean	242	126	2.4	6.5	28.8	1464	2.4	619	11.6
1	S.D.	192	120	1.1	4.1	0.9	1861	1.9	97	1.8
(107 days)	Min. Value	24	6	0	1	25.4	0	0	0	0
	Max. Value	962	540	6.0	14	30.3	9082	9	5997	47.9
Sardines	Mean	273	168	3.3	6.9	28.5	1399	3.0	471	8.3
2	S.D.	223	123	1.3	4.3	0.5	1192	2.2	102	1.8
(37 days)	Min. Value	13	7	0.5	1	27.5	2	1	18	0.3
	Max. Value	848	420	6.0	14	29.6	4755	8	1940	25.40
Hardyheads	Mean	192	57	2.6	4.3	29.2	252	1.0	252	4.4
3	S.D.	188	42	1.3	3.4	0.8	298	1.0	102	1.7
(15 days)	Min. Value	9	6	0	1	27.8	0	0	0	0
	Max. Value	662	132	4.5	10	30.1	1021	3	536	13.6
Mollies	Mean	324	64	2.6	9.9	28.8	726	2.6	274	11.3
4	S.D.	161	47	0.9	3.7	0.6	997	2.0	114	4.7
(17 days)	Min. Value	21	12	1.0	1	27.8	0	0	0	0
	Max. Value	591	150	4.0	14	29.6	3510	7	805	32.3
Milkfish	Mean	396	87	3.0	7.1	28.2	1208	2.8	439	13.9
5	S.D.	231	74	1.3	4.3	1.0	1179	2.2	139	4.4
(20 days)	Min. Value	30	2	0.5	1	26.4	0	0	0	0
	Max. Value	747	315	6.0	14	29.8	3525	7	1794	59.8
Sprats	Mean	144	75	2.4	4.6	28.7	775	1.7	459	10.4
6	S.D.	146	79	1.0	3.5	1.0	1095	1.2	119	2.7
(45 days)	Min. Value	11	6	0	1	24.8	0	0	0	0
	Max. Value	750	450	5.5	14	30.4	6206	4	6206	48.4
Total	Mean	244	111	2.6	6.3	28.7	1177	2.3	511	10.5
241 days	S.D.	201	108	1.2	4.1	0.8	1512	1.9	53	1.1
	Min. Value	9	2	0	1	24.8	0	0	0	0
	Max. Value	962	540	6.0	14	30.4	9082	9	6206	59.8